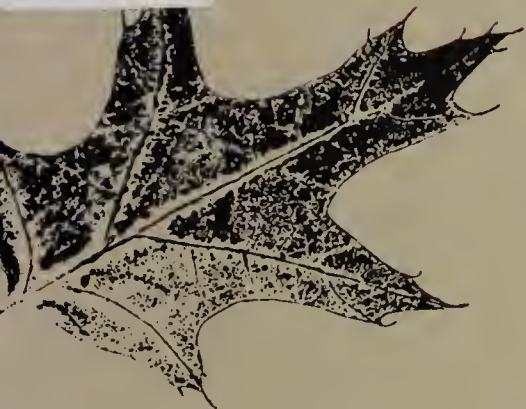


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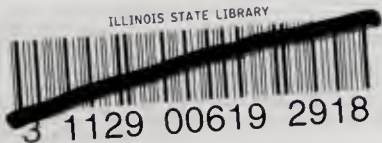
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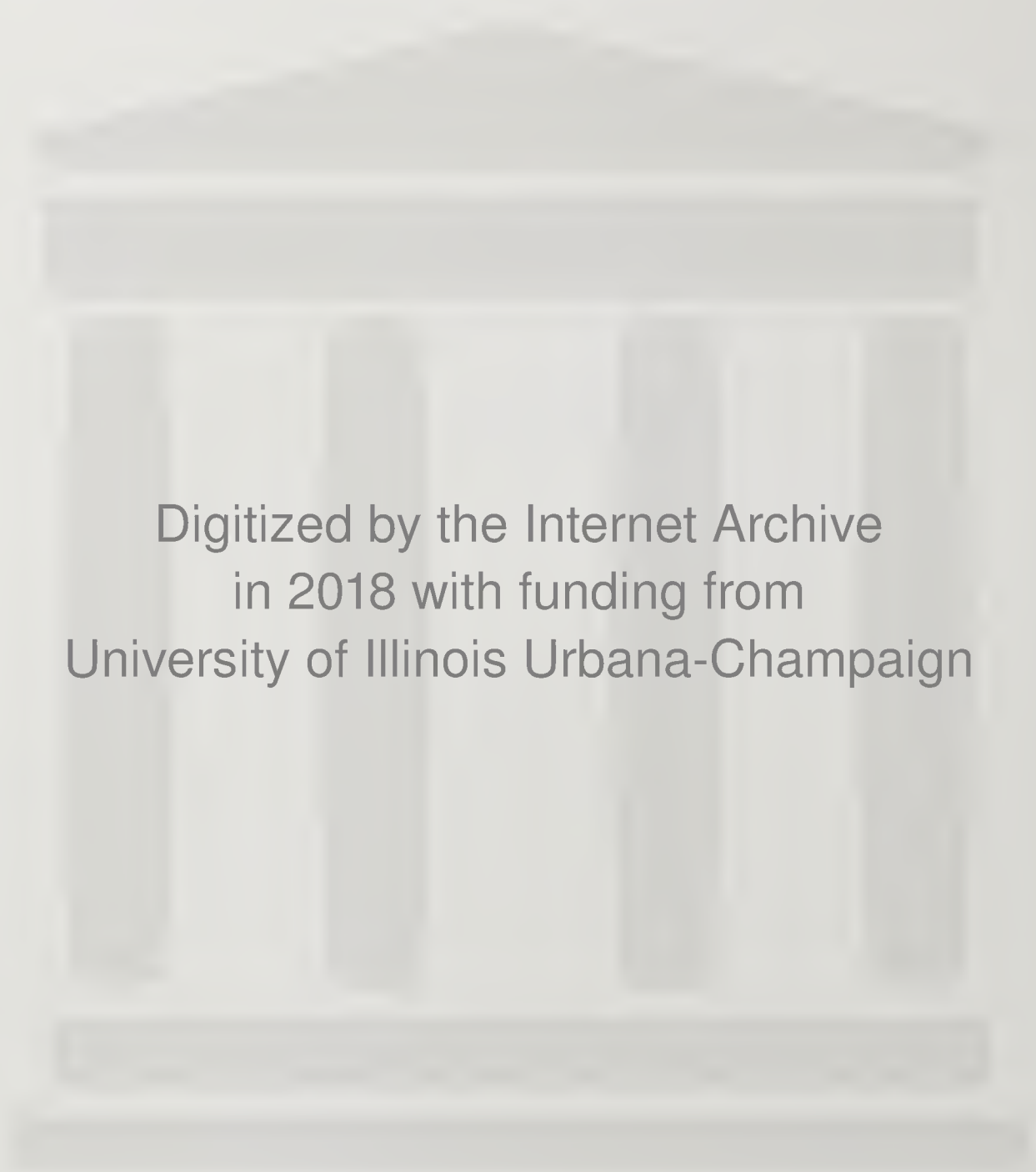
The State of Illinois
Department of Energy and Natural Resources

Contents

Introduction 1
Aquatic Biology 5
Botany and Plant Pathology 14
Economic Entomology 18
Faunistic Surveys and Insect Identification 27
Wildlife Research 33
Financial Statement 39
Professional Activities 41

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INTRODUCTION

Lorin I. Nevling, Chief

The past year was one of proud achievement in innovative research, renewed educational efforts throughout the State, and the thoughtful development of an internal organizational structure that will assure future success.

Although 1988 was a rather difficult year financially with extremely modest budgetary increases provided by the Illinois General Assembly, this constraint made the year administratively and operationally challenging and proved to be enormously satisfying because of the continued outstanding accomplishments of the staff.

Research Achievements

The Survey's research effort, although organized into various disciplines and grouped into five scientific sections, transcends these rather artificial boundaries and reflects a much broader outlook. I cannot mention here all the significant research accomplishments of the past year, but I will note briefly various projects that have or will have environmental and economic significance and suggest how the Survey aids in the guardianship of the State's biotic resources through liaison with other agencies and partnership with the citizens of Illinois.

The Survey plays a significant role in the Environmental Management Program, a long-term project established by the Congress to protect the resources of the upper Mississippi River and guide future river management. Through yearly qualitative and quantitative surveys that document changes in vegetation in various pools of the upper Mississippi, Survey scientists are providing ecological indicators of change over time. In this way, the health of the river system can be assessed.

An estimated 1,500 agrochemical retail facilities are located in Illinois, and the pesticide waste that accumulates at these sites is enormous. Researchers at the Survey have investigated the feasibility of cleaning up the herbicides at such sites by excavating contaminated soil, spreading it on nearby fields, and using various microorganisms to accelerate the degradation of these hazardous chemicals. Given the potential and actual danger to groundwater when wastes contain-

ing highly persistent herbicides are deposited in landfills, a biological solution is of the utmost importance. Maintaining a healthy groundwater system is a pressing problem in Illinois.

With the era of satellite imagery and geographic information system technologies has come an unprecedented opportunity to quantify and analyze urban land-cover patterns with efficiency and economy. Sadly, Illinois ranks 47th among states in publicly owned open space per person. A team of Survey researchers working with forty municipalities within the Chicago Metropolitan Area and east-central Illinois are studying the urban landscape, especially the types and quantities of land cover that are being converted to urban use. In this way the open space available to residents can be correlated with local expenditures for forestry and natural areas programs and guide planning efforts to enhance the quality of life for urban dwellers.

A significant information gap exists between researchers and the managers of freshwater fisheries. Managers typically undertake regular surveys of fish populations and conduct periodic estimates of angler yield and effort. Researchers, on the other hand, undertake special projects, typically making detailed measurements over a short term on a limited number of bodies of water. To increase communication between managers and researchers, staff from the Illinois Department of Conservation and the Survey cooperated in the development and implementation of the Fisheries Analysis System. This computerized data management tool is designed to analyze local and statewide data sets for both management and research purposes. The design features include local data entry and analysis that permits district biologists to make more accurate and timely management decisions; the ability to upload data to a minicomputer to create a statewide data base; and the capacity to download data to microcomputers. Information is entered using programs that follow the format of field data sheets, thereby permitting direct checking and verification of data. Analytical outputs include stock indices, condition tables and

graphs, length frequency tables and histograms, length-weight plots, graphs of individual and mean length at age, and tables of catch per unit effort. The capabilities of the system permit summary analyses to be made and allow for merging with our statewide relational data base on a minicomputer where hydrological, meteorological, and geomorphological data can be integrated. The ultimate beneficiary of this impressive system is the Illinois angler.

Two highly significant problems that could have a substantial impact on public health in Illinois were discovered this year: the spread of the potentially health-threatening Asian tiger mosquito and the confirmation of the expected entry of Lyme disease into the State.

The Asian tiger mosquito, a container-inhabiting mosquito capable of carrying twenty-six viruses known to affect humans, is rapidly colonizing urban areas in Illinois. The Survey took an active role in the Governor's committee to prepare legislation addressing the storage of scrap tires and the associated health threat of mosquitoes that use these tires as larval habitat. In addition to the tiger mosquito, four other Illinois mosquitoes that transmit human viral diseases use tires similarly. The legislation developed by the committee received Governor Thompson's signature and will provide funding for an active research program on tire-breeding mosquitoes and other arthropods.

Prior to November 1988, the deer tick, a primary vector of Lyme disease, had been collected in only two northern Illinois counties. Teams of Survey and University of

Illinois researchers along with Department of Conservation personnel and interested volunteers examined over 3,000 deer at various checkpoints in more than fifty counties. As a result of this endeavor, the known range of the deer tick currently totals twelve counties. Clearly an invader from the north, the tick is now known as far south as Piatt County. In addition, the lone star tick, possibly another vector of Lyme disease, is expanding its range from southern Illinois northward. Both ticks have fast become a matter for serious concern as cases of Lyme disease begin to be diagnosed in the State.

Above average temperature, widespread drought, and elevated levels of air pollutants during the summer of 1988 were widely reported in the media as consequences of a major climate change attributed to the greenhouse effect. The implications of changing global climate patterns for agriculture and food production in Illinois and for the abundance and vitality of the tens of thousands of organisms of the State are critical but largely unknown. Survey researchers have begun to investigate the effects of atmospheric pollution on plants from both natural and agricultural ecosystems. At various levels of stress induced by drought and air pollution, they found that photosynthesis was inhibited, that certain garden vegetable cultivars were susceptible to ozone stress, and that the competitive ability of native grasses was adversely affected. The differential responses of individual plant species to these environmental stresses may ultimately alter community structure in natural and agricultural ecosystems and thereby diminish the ability of various species to prosper.

Illinois is notable for the variety of organisms that exist within its boundaries, and the Survey is systematically cataloging groups of special significance and creating easily accessible data bases for use by other state and private agencies, researchers, and interested citizens. One such data base under development is for the Lepidoptera (butterflies and moths), of which at least 2,000 species occur in Illinois. The data base will allow collation of species distribution, seasonal occurrences, host preferences, and habitat requirements. Such information is useful in establishing the environmental health of Illinois and in developing land-use policies that protect Illinois Lepidoptera.

Prairie-chickens on their booming grounds in spring are one of the most intriguing sights in nature. Because of the highly endangered status of the remnant prairie-chicken population of Illinois, however, few people have had an opportunity to view this spectacle. The high level of cooperation between the Survey, the Illinois Department of Conservation, and The Nature Conservancy in research and management is a basic ingredient in the attempt to increase prairie-chicken numbers. Through these efforts, including studies of the parasitism of prairie-chicken nests by the introduced ring-necked pheasant, this native bird has a chance to remain a part of the broad array of prairie fauna and flora supported on sanctuary land for the benefit of Illinoisians for years to come.

Lead poisoning has caused mortality in waterfowl for more than a century. Birds fall prey to lead poisoning by ingesting spent lead shot while feeding. In a recent publication, *Lead Poisoning in Illinois Waterfowl (1977-1988) and the Implementation of Nontoxic Shot Regulations*, Survey researchers documented how studies made in Illinois and elsewhere were incorporated into complex policy-making decisions over the past decade—the critical decade of transition in the adoption of nontoxic shot regulations for hunting waterfowl in the United States. In 1986, the Fish and Wildlife Service initiated a nationwide phase-out of lead shot for waterfowl hunting that will culminate in 1991. Survey research played a pivotal role in the development of that national policy.

Historically, Illinois streams supported a diverse freshwater mussel fauna. In more recent decades, however, many species have become rare and are in danger of extirpation. To understand these declines and their underlying causes, a survey of Illinois mussels is underway. The most recent component of this statewide study was a survey of the Little Wabash River where only twenty-six of the forty species known to have lived there were found alive. This information is consistent with other recent mussel surveys and reflects the need for increased protection of aquatic habitats and the improvement of water quality in Illinois rivers and streams.

An unusual project for the Survey that relied on the capabilities of the Illinois Geographic Information System was one to assist the East St. Louis Revitalization Project. Efforts were directed to the siting of two facilities: a



modular housing factory and a demonstration community housing project. The siting of the factory was based primarily on such desirable landscape features as proximity to rail lines and interstate interchanges. In contrast, the siting of the housing project was based on landscape features to be avoided— flood zones and truck routes, for example. Successful planning is a dynamic, cooperative process, and it was the Survey's intent to demonstrate to the East St. Louis community the value of the Illinois Geographic Information System as a planning tool. In this process, a data base for East St. Louis was compiled that will serve as the basis for other community planning applications.

Education Outreach

In an address to a conference of Illinois high school teachers in 1928, Stephen A. Forbes noted that the institution of which he was founder and chief should "take a first step towards establishing a much closer relation than now exists between the State Natural History Survey and the biological work of the Illinois high schools." That relationship is being strengthened today by a renewed educational thrust at the Survey. Two sets of curriculum materials for middle-school students have been produced: *Legacy of a Pest*, which discusses the environmental and ecological problems involved in coping with an introduced pest, and *The Illinois River: A Lesson to be Learned*, which reviews events that have contributed to the river's decline. In addition, Survey scientists assisted elementary teachers from Champaign Unit Four School District in the development of curricular materials for the natural sciences at three grade levels. A third activity, the Survey's participation in Champaign's Marketplace Nature Expo provided an opportunity to reach a large segment of the local population. Over fifty members of the Survey participated in the preparation and operation of the display, and the exhibits and demonstrations were enthusiastically received by children and adults alike.

The acquisition of equipment to facilitate the staging of multi-image slide presentations has enhanced our scientific lectures and given them considerable public appeal. We believe that the technique not only expedites learning but makes the process more enjoyable. Survey scientists addressed dozens of public forums throughout the year—from scout meetings and grade-school classes to meetings of

agriculturists, garden clubs, the business community, and graduate students across the State and in neighboring states and Canada.

Sustained and vigorous educational efforts are necessary if the scientists of today are to improve scientific literacy among young Americans and foster an appreciation for the intricacies and fragility of the natural environment. An informed citizenry is essential if scientists are to address the very real and urgent biological problems of this planet.

Publication has long been the primary medium through which Survey scientists communicate the results of their research to scientific colleagues and to the public. As members of a biological research organization, the staff not only seeks new knowledge but also applies existing information in new ways. As members of a public service agency, they actively convey research results and management recommendations to municipalities, professional groups, homeowners, and public and private agencies. No citizen of the State is untouched by this communication network. The Survey's publication record remained at an outstanding level again this year, and I am especially proud of the number of articles placed in scientific journals of international repute. In-house publications of the Survey are distributed to 725 educational and research institutions as part of an ongoing exchange program, and the popular *Survey Reports* is distributed without charge to 4,200 citizens. In addition, a badly needed update of the *Publications of the Illinois Natural History Survey 1876–1988* was issued. Efforts are underway to increase the attractiveness

and usefulness of our publications, and I hope this Annual Report will be judged by the reader as a worthy example of these efforts.

The staff continued to work closely with the Society for the Illinois Scientific Surveys "to promote the work of the three Illinois Surveys and to foster an appreciation and understanding of the natural resources of Illinois." Major efforts are underway to increase the visibility of the Surveys, to expedite the transfer of information, and to assist in environmental and science education. This year, the Society assembled and distributed a natural resources gift basket from the three Surveys and the Society to legislators, the Governor, and others. These baskets proved a great success. In addition, the Society publishes *The Nature of Illinois*, a full-color quarterly in which we have a regular column and periodic articles. A monthly tip sheet of current topics being addressed by the Surveys is sent by the Society to more than 700 print and electronic media throughout the State.

Enhanced Facilities

From time to time, but not often enough, we are able to improve our workplace. Last year I reported the completion of a major expansion and refurbishing of Survey facilities at Havana, Illinois. On 5 May 1989, we celebrated the Golden Anniversary of this field station, dedicated the new addition, and took the opportunity to name the expanded and improved facility the Stephen A. Forbes Biological Station in honor of the founding father of the Survey. Colleagues, friends, and former staff from across the nation gathered for the celebration. A special publication, *Forbes Biological Station: The Past and the*



Promise, was released to coincide with the event. Governor Thompson issued a proclamation citing the day as Stephen A. Forbes Biological Station Day, and the American Benthological Society presented a plaque in honor of the founding of their organization at the Station in 1953. Many of the founding members were present for the presentation. The stage is now set for another half-century of research to seek out the secrets of the Illinois River, to focus attention on reversing the slide to extinction, and perhaps, to pursue the goal of restoring past glories.

I am pleased to report that an electrically driven compactor system to house the six million specimens of the Survey's insect collection, the sixth largest in the United States, has been installed. The compactors house the collection securely and so efficiently that badly needed space for collection growth (an additional 4,000 museum drawers), two offices, and a visitor's workspace were also accommodated.

The nearly dilapidated greenhouses adjacent to the Natural Resources Building received a major upgrade from the University of Illinois this past spring with reglazing, painting, and the installation of an innovative new plastic roof. Our scientists will once again be able to conduct experiments in a safe environment.

Planning for the replacement of the now largely outmoded internal computer network was concluded, and we look forward to the completion of the installation. The network will include the Natural Resources Building and the several buildings that house the Survey Annex. Internal communication will

be greatly improved through central file servers and increased productivity is anticipated.

This year marked a major step forward in the editorial office with the initiation of computer output directly interfaced with the printer. This technique is highly cost effective because it eliminates galley proof and the laborious paste-up process. The first publication produced by this method was a comprehensive study and taxonomic revision of asters in Illinois released in May 1989. Another technological advancement related to the publication program was the use of the Geographic Information System computer to generate four-color separations for the production of some sixty maps for a soon-to-be-released book on the forest resources of Illinois. The use of this process resulted in substantial financial savings.

The Survey received a valuable gift of the photographic collection of Robert Evers, a former member of the Section of Botany and Plant Pathology. The 2,900 fully indexed color slides of plants, localities, and portraits of scientific personages are extremely important because many of the images serve as benchmarks and help to establish changes over time in sensitive Illinois habitats.

Maintenance of the Survey library's outstanding collection of written materials was the main task of library personnel for the past year. Through their creative efforts at reorganization, badly needed additional shelving space was provided. High-quality bibliographic services helped scientists manage the information explosion in the sciences, and

ongoing computerization continued to provide ready access to materials at any of the libraries of the University and the State. The library remains an enjoyable place to work and provides challenging opportunities for professional growth.

Administration and Personnel
Several changes in the leadership of the Survey occurred during the fiscal year. Drs. Robert Gorden and Wallace LaBerge were succeeded by Drs. Lewis Osborne and Lawrence Page as heads of the sections of Aquatic Biology and of Faunistic Surveys and Insect Identification, respectively. Drs. Glen Sanderson and Wallace LaBerge were promoted to Principal Scientist, the highest level of scientific achievement recognized in the Survey. It is also my sad duty to report the passing of Dr. Carl Kirkpatrick, an Affiliate in the Section of Wildlife Biology since 1987.

The leadership of the Survey devoted considerable energies to examining the effectiveness of our internal organizational structure. As a result, changes were proposed to the staff and discussed in open forum. Final recommendations were approved by the Board of Natural Resources and Conservation for implementation at the beginning of fiscal year 1990. The Survey's committee structure was also revised, and a system of internal affiliates was proposed whereby staff members may request appointments in more than one section in order to achieve close collaboration with colleagues. Together, these changes are intended to help us shape our future and meet the unseen challenges that are certain to face Illinoisians in the years ahead.

An Invitation to Read On
Never before has dedication to the Survey's legislative mandate to develop, maintain, and conserve the living organisms of the State along with the habitats, ecosystems, and landscapes that sustain those organisms been of greater significance to the citizens of Illinois. You are invited to read our Annual Report and share in the notable progress we have made during the past year to meet this challenge. The research and educational efforts underway are of such diversity that I am certain you will find projects that will spark your interest and stir your imagination.





AQUATIC BIOLOGY

Lewis L. Osborne, Head

The mission of the Section of Aquatic Biology is to conduct basic and applied research related to the aquatic ecosystems of Illinois and to investigate the biology of the associated flora and fauna.

Public Service

During the past year, members of the Aquatic Biology Section participated in numerous and varied public service activities, including the identification of aquatic organisms in response to queries from the public, presentations to a variety of audiences on the aquatic resources of Illinois, and service on technical advisory panels and committees of professional societies. Of all these activities, however, the most important service to the citizens of the State was the preparation of recommendations related to environmental management, recommendations based on the scientific research of the Section. Recently, for example, Governor Thompson signed a bill authorizing the Illinois Department of Transportation to establish a permit system to regulate the withdrawal of surface waters from the streams and rivers of the State in order to ensure sufficient water for the propagation of aquatic life. This bill, introduced by Representative Helen Satterthwaite, was developed with the technical assistance of Drs. R. Weldon Larimore and Lewis L. Osborne.

Four research projects of the past year typify how the work of aquatic biologists addresses environmental issues of direct and immediate concern to all Illinoisians. Dr. Peter B. Bayley is conducting extensive creel surveys of several state-managed lakes in cooperation with the Illinois Department of Conservation. The results of this study will permit Conservation personnel to evaluate present management strategies for sport-fish populations and to devise new strategies that will respond to the concerns of Illinois fishing enthusiasts. Dr. Lewis L. Osborne, in cooperation with Dr. David Kovacic of the University of Illinois at Urbana-Champaign, is investigating the effectiveness of riparian buffer strips in reducing pollution originating from nonpoint sources associated with agricultural practices. Results should provide Illinois with an economical means of improving surface-water

quality. At the Lake Michigan field station, Dr. William H. Horns, in cooperation with the Illinois Department of Conservation, is conducting several research studies that will improve the management of Lake Michigan sport fisheries. Finally, Drs. Richard E. Sparks and Philippe E. Ross and Mr. K. Douglas Blodgett are studying contaminants in the Illinois River in order to provide recommendations to state and federal agencies regarding the restoration and improvement of that waterway.

Efforts of aquatic biologists are also directed toward educating the public regarding environmental issues—through talks and seminars and by accompanying students on field trips. During the summer of 1989, film crews from the British Broadcasting Corporation accompanied Dr. David P. Philipp and colleagues to Queen's University Biological Station at Lake Opinicon to film the spawning behavior of bluegill. Dr. Philipp's research, in cooperation with Dr. Mart Gross from the University of Toronto, will be highlighted in a segment of David Attenborough's new BBC series *Evolution and Behavior*, which will be aired in 1990.

Other direct service to the public includes responding to questions related to aquatic life and management issues. During the past year, the Section office in Champaign answered more than thirty inquiries related to lake and pond management and to the potential hazards to aquatic systems of urban and agricultural land practices. Ms. Pamela P. Tazik identified aquatic plants for numerous private lake and pond homeowners; Drs. Steven L. Kohler and Lewis L. Osborne identified aquatic macroinvertebrates for the public, and Mr. Jens Sandberger, in cooperation with Dr. Sue Wood from the Section of Wildlife Research, analyzed water samples from several private wells to determine the presence of chemical contamination.

In addition to these public service activities, staff members were active in professional societies, including the American Fisheries Society, the North American Benthological Society, and the Society for Environmental

Toxicology and Contamination. Their activities ranged from serving as officers to chairs and members of committees. Section staff were also members of several state and federal advisory boards and technical panels, including the State Watershed Priority Subcommittee, the State Instream Flow Task Force, the Illinois Stream Corridor Advisory Committee, the State Aquaculture Advisory Committee, the Great Lakes Contaminated Sediment Toxicity/Chemistry Advisory Panel, and the Upper Mississippi Technical Committee.

Several members of the Aquatic Biology Section were active in graduate education at the University of Illinois, supervising the work of twelve graduate students and conducting seminar courses. Members of the staff were also affiliated with the Department of Ecology, Ethology, and Evolution, the Department of Animal Sciences, the Department of Urban and Regional Planning, and the Institute for Environmental Studies at the University of Illinois; with the Department of Zoology at Eastern Illinois University; and with the Department of Biology at Western Illinois University.

Special Recognition

During the past year, every professional scientist in the Aquatic Biology Section was awarded a major research grant or contract from a state or federal agency, including the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the National Science Foundation, the Illinois Department of Conservation, and the Illinois Department of Energy and Natural Resources. In addition to these awards, members of the

staff were recognized for a number of scientific activities that reflect their outstanding abilities over a wide range of career levels.

In the fall of 1988 and spring of 1989, Dr. David P. Philipp was selected by the Canadian National Museum of Natural Sciences as a featured lecturer in the Zoological Education Trust Lecture Tour. Dr. Philipp presented a series of talks at nine universities across Canada concerning hazards associated with the introduction of species.

Dr. R. Weldon Larimore was honored at the 35th Annual Meeting of the North American Benthological Society as a founding member. A plaque commemorating the founding and a framed photograph of the original thirteen members permanently resides at the Stephen A. Forbes Biological Station, the site of the Society's first meeting. In recognition of his contribution to warmwater streams biology over the past forty years, Dr. Larimore was also selected to chair the Plenary Session of the 1989 Midwest Fish and Wildlife Society.

Dr. Richard E. Sparks was appointed to the National Research Council's Committee on Restoration of Aquatic Systems: Science, Technology, and Public Policy. His selection was based on his extensive research on large river systems and his recent efforts to restore the ecosystems of the Illinois River.

In recognition of her research on the ecology of aquatic macrophytes in Illinois, her previous service to the Society, and her leadership ability, Ms. Pamela P. Tazik was elected President of the Illinois Lake Management Society. The goal of the Society

is to promote research and disseminate information on techniques for managing small ponds and lakes throughout the State.

Drs. Philippe E. Ross, Robert A. Herendeen, and Lewis L. Osborne were also recognized for technical expertise and service during the past year. Dr. Ross was chosen a Senior Environmental Advisor to the U.S. Environmental Protection Agency and is assisting with the toxicity assessment and clean-up of contaminated sediments in the Great Lakes. Dr. Herendeen received a travel grant from the National Science Foundation to collaborate with colleagues in Denmark and Sweden in an attempt to develop systemwide indicators that will describe and predict ecosystem behavior under perturbation. Dr. Osborne, Acting Head of the Section, was elected to the Executive Committee of the North American Benthological Society for a second consecutive year.

Several scientists participated in graduate education programs and served as advisors and directors of student research. This past year, Mr. Russell Forrest, a graduate student in Environmental Planning at the University of Illinois and a student of Dr. Osborne, was awarded the Best Departmental Thesis Award. The educational achievements and professional promise of two research biologists in the Section were also recognized this past year: Mr. Douglas J. Austen and Ms. Julie Claussen were co-recipients of the American Fisheries Society's Skinner Travel Award for Graduate Research Achievement. As a result, both attended this year's annual meeting in Anchorage, Alaska. Mr. Austen works with Dr. Peter B. Bayley and Ms. Claussen works with Dr. David P. Philipp. Mr. Pawel Kindler and Mr. Michael Nedbal, graduate students under the supervision of Dr. Philipp, were awarded Sigma Xi grants from the University of Illinois to help offset expenses of thesis research.

Research Reports

The more than fifty research reports that follow document the range of activities undertaken by the Section of Aquatic Biology during the past fiscal year. The issues they address are of interest to all Illinoisians—farmers, fishing enthusiasts, aquaculturists, and environmentalists alike. Maintaining and improving the quality of the streams and rivers of Illinois and restoring their wetlands are challenges we cannot afford to ignore.



Eliminating gear bias

P. Bayley, D. Dowling, J. Peterson

The diversity and community composition of fish species within a stream reflect its "well-being," but sampling gear inevitably distort true abundances and species counts. Such biases are governed by stream size, habitat structure, water properties, and sizes and species of fish. To correct sampling data, researchers are calculating efficiencies of standardized fish sampling gear—the electric seine, the boat electroshocker, the backpack shocker, the minnow seine, and rotenone. More than 90 calibrations were made on streams and rivers over the past two and a half years. Ultimately these studies will help us to improve the recreational and aesthetic qualities of Illinois streams.

Managing Illinois impoundments

P. Bayley

Growing numbers of anglers are making increased demands on the water resources of Illinois, but managers are often uncertain how fish communities will respond to changes in fishing pressure. Creel surveys are determining the effect of fishing effort on fish populations, and data on water depth and bottom contour and composition are being collected from some 120 impoundments. After these data are entered on the Illinois geographic information system, managers will be able to determine more precisely how physical and chemical differences affect fish communities and angling effort.

Ammonia spill in Copper Slough

S. Kohler, L. Osborne

In July 1988, Kraft Foods accidentally discharged 400 pounds of industrial ammonia into Copper Slough, a tributary of the Kaskaskia River, one of the finest stream fisheries in central Illinois. The spill eliminated most stream life for approximately 20 miles downstream. Kraft requested the Survey to assess the recovery of fish and macroinvertebrate communities through March 1991, thereby providing an opportunity to test fundamental ecological paradigms regarding the recovery of damaged ecosystems. The study will also provide the Illinois Department of Conservation and Kraft with an estimate of the restocking needed to return the fishery to its pre-spill condition.

Food sources for aquaculture

P. Brown, P. Tazik

Aquaculture is a growing young industry in the State and native crayfish are one of its potential commercial products. Economical and palatable food sources, however, are a prerequisite. Crayfish are thought to be omnivores, but the importance of various foods in their diet is poorly understood. Male and female *Orconectes virilis* were fed 14 aquatic macrophyte species (e.g., cattail, bulrush, arrowhead, eel grass, and American lotus). These plants were consumed at relatively low rates and proved relatively unpalatable to the crayfish. Thus, macrophytes do not appear to be a suitable food for the aquaculture of this species.

Treated straw as an aquaculture food

P. Brown, R. Gorden, D. Buck

Cost-effective feeds are of interest to the growing number of Illinois aquaculturists. In cooperation with scientists at the University of Arkansas, Survey researchers evaluated straw treated with hydrogen peroxide as an aquaculture feed. In initial tests, crayfish and tilapia fed treated straw grew well. In extended tests, however, they failed to show an acceptable rate of growth. Although treated straw was an inexpensive food, its ability to sustain growth was not acceptable.

Photodegradable and biodegradable plastic

R. Gorden, K. Leonas

Plastic wastes are accumulating in the nation's landfills at an alarming rate, and photo- and biodegradable plastics offer a partial solution to the problem. Under the sponsorship of Dow Chemical, the effects of ultraviolet light and heterotrophic bacterial populations on the decomposition of seven plastics were determined. One degraded to the brittle point within 12 hours of exposure to intense ultraviolet light in an aquatic environment; bacteria attached themselves to the underside of the plastic within 4–6 hours and were abundant within 12 hours. No other plastic degraded to the brittle point within 240 hours of exposure to ultraviolet light.

Systemwide indicators in ecosystems

R. Herendeen

This study in collaboration with projects in Scandanavia explores the use of systemwide indicators (quantities that summarize the flow of energy and materials between the components of ecosystems). Although such indicators are useful in comparing ecosystems and characterizing them as more or less disturbed, their value in generating principles capable of predicting responses to perturbations over time scales of interest to managers has not been shown. Work on the analysis of flow and stock distributions in ecosystems continues, and a framework has been developed to compare patterns expressed in terms of energy with those expressed in terms of nutrients such as nitrogen.

Fish simulation

R. Herendeen, P. Bayley

To determine the bias of fish sampling gear, a model has been developed that simulates the relationship between the number and size of fish captured with a purse seine and the number and size of fish actually present in the stream reach being sampled. To determine the true size distribution of fish versus the captured distribution, scientists must take into account the variation in a fish's evasive ability with size, swimming speed, and behavior. The model does just that by simulating in detail a fish's evasive behavior, including the random aspects of that behavior. Field data were used to verify the validity of the model.

Sport fishing in Lake Michigan

W. Horns

More than 5,000 angling parties have been interviewed annually to provide estimates of sport fishing activity, harvest, and expenditure in the Illinois waters of Lake Michigan. The survey includes pedestrian fishing and fishing from nonchartered boats. In recent years, total fishing effort approached 2 million angler-hours with annual catches of yellow perch exceeding 1.7 million. Catches of chinook and coho salmon fluctuated widely, with an estimated noncharter catch of only 13,700 coho salmon in 1988. Expenditures for boats, motors, trailers, fishing gear, and automobile gas exceeded \$7 million, with the value of the sport-fishing harvest estimated at \$3.9 million.

Incidental captures of salmon and trout

W. Horns

Survey researchers are hitching rides on commercial fishing boats to determine the number of incidental captures of salmon and trout in gill nets used to harvest yellow perch and bloaters. Undoubtedly, commercial fishing operations kill salmon and trout, but commercial and sport fishermen disagree sharply about the numbers. This study will provide estimates of the numbers, sizes, and ages of salmon and trout killed in commercial nets. If incidental captures are high, future studies will determine if the problem can be alleviated by restricting commercial fishing during certain times of the year.

Predation on yearling chinook salmon

W. Horns

At the time of stocking, chinook salmon are vulnerable to predation by adult yellow perch. The current abundance of yellow perch in Lake Michigan, therefore, may contribute to the current decline of chinook salmon. Researchers using gill nets are collecting yellow perch in the vicinity of chinook salmon stockings; they later dissect the fish and examine the contents of their stomachs for the presence of yearling chinook salmon. These data in combination with data from a study of yellow perch abundance and movements will help to evaluate the impact of yellow perch on the salmon fishery.

Yellow perch in Lake Michigan

W. Horns

During the 1980s, the sport fishery for yellow perch in the Illinois waters of Lake Michigan grew in numbers harvested (1.7 million annually) and in participation by Illinois anglers. The annual commercial harvest increased from 46,000 pounds in 1979 to over 150,000 pounds in recent years. The impact of the rejuvenated fishery has been difficult to assess because data on the size of fishable populations and their movements in Lake Michigan are lacking. Researchers are now tagging 15,000–25,000 yellow perch annually. The locations of tagged fish recaptured by sport and commercial fishermen and by biologists will then be used to assess the status of the yellow perch fishery.

Predation by alewives

W. Horns

The abundance of yellow perch in Lake Michigan fluctuates unpredictably, possibly in part because of fluctuations in the abundance of alewives. In recent decades, yellow perch have been most abundant in years when alewives were scarce. Alewives are known to eat large numbers of yellow perch but only when they are less than a third of an inch in length. To obtain more precise information, researchers are investigating the timing and magnitude of yellow perch hatches and the timing and extent of alewife predation on newly hatched yellow perch. Results of this study should help to determine the role of alewife predation in regulating the yellow perch population in Lake Michigan.

Yellow perch and zooplankton

W. Horns

Over the past thirty years, the abundance and growth rates of yellow perch have fluctuated widely in Lake Michigan. When young yellow perch are abundant, they graze heavily on the zooplankton of the near-shore area and may deplete that food resource, thereby limiting their own growth rates. Slow growth, in turn, may affect population abundance because the period when yellow perch are small and vulnerable to alewives or other predators would be extended. To explore these relationships more fully, researchers are monitoring zooplankton populations and the growth rates of yellow perch in two areas of Lake Michigan.

Decline in size of yellow perch

W. Horns

The U.S. Fish and Wildlife Service reported that the 1983 year class of yellow perch collected in the Michigan waters of Lake Michigan in the fall of 1984 were one-fourth as heavy as fish of the same age collected in the same area during the 1970s. With the help of biologists in the states bordering Lake Michigan, year-to-year and geographic differences in size-at-age yellow perch were studied from 1986 through 1988. By examining annual rings in the inner-ear bones of these fish, they were able to infer age and growth histories and concluded that yellow perch of the 1983 year class were abundant and small, particularly in the Michigan waters, compared with those of the 1984 and 1982 year classes.

Lake trout on Julian's Reef

W. Horns

Over 30 million lake trout have been stocked in the Great Lakes since 1986 in an effort to reestablish self-sustaining populations. More than 1 million were stocked over Julian's Reef in the Illinois waters of Lake Michigan. Evidence of natural reproduction by stocked trout in the Great Lakes has been scant, except in Lake Superior. During 1985–1988, researchers attempted to recover spawned eggs from Julian's Reef. The technique they used was successful in Lake Ontario, but no eggs were recovered from the reef although mature and gravid trout aggregate there in fall. Because trout are highly selective in choosing spawning sites, scientists speculate they may have missed the areas chosen by the fish.

Kankakee River fishes

R. Larimore, J. Petersen

The impact of the Braidwood Nuclear Generating Station and its riverside intake and discharge structures on the fishes of the Kankakee River is not known. Fortunately, annual studies of the river were conducted by Survey staff from 1977 through 1987, thus providing ten years of pre-operation data on the river's fishery. A long-term data set such as this is rare in itself, but this set is unique because sampling methods and effort remained constant throughout the decade. After the plant began generating electricity in 1988, aquatic ecologists began collecting post-operation data. Pre- and post-data can now be used to measure the impact of the station on fish populations of the Kankakee.

Wetland restoration

G. Messer, P. Tazik

Wetlands once covered 215 million acres of the nation; today only 99 million remain. The value of wetlands as wildlife habitat and in water purification, sediment retention, and flood and erosion control has only recently been recognized. National environmental policy now protects wetlands, and projects that would impinge on them must guarantee that wetland functions lost because of their activities will be replaced. Researchers examined case studies and found that restoration procedures did not result in structurally and functionally balanced wetlands. Their findings suggest that alternate sites be used when possible, that site designs be improved, and that restoration be closely supervised.

Threatened and endangered species

L. Osborne, S. Kohler

The Endangered Species Act requires federal agencies to protect threatened and endangered species on lands under their control. Many such species occur on military installations throughout the country. To minimize the effect of military activities on these species, army personnel need specific information about each species and its habitat. Survey researchers responded by developing an annotated directory of threatened and endangered species at approximately 60 army installations east of the Mississippi River. They are also providing ecological information pertinent to the management and recovery of these species.

Aquatic plants and oil spills

P. Tazik, L. Osborne

Aquatic macrophytes supply food, oxygen, and habitat structure for heterotrophic organisms in lake ecosystems, but little is known about their response to oil spills; even less is known about their rate of recovery following exposure to crude oil. Species composition, abundance, and distribution of several aquatic macrophytes in Newton Lake, Illinois—the site of a major oil spill in 1985—are being assessed over the next three years. In addition, low-altitude aerial photographs and data from the Illinois geographic information system will document changes in the extent and location of aquatic vegetation throughout the lake.

Fish in Champaign County

L. Osborne, P. Bayley, R. Larimore

Although legislation has been passed to protect and restore the environment, little information is available on the benefits achieved, particularly the impact on fish in streams. For the past two years, fish communities at 130 Champaign County locations that had been sampled in 1959 were resampled using identical procedures. Historical data, however, go back even farther because in 1959 Survey ecologists sampled streams that had been examined in the 1890s and 1930s. Comparisons between the data on current fish communities and the historical data will permit one of the first assessments of long-term changes in fish populations on a significant geographic scale.

Riparian vegetation

L. Osborne, D. Kovacic

Agricultural activities are major contributors to the degradation of surficial water quality in the U.S. and the principal culprit in Illinois. Economically feasible techniques to reduce that impact are urgently needed. An investigation of a Champaign County stream will determine the value of streamside vegetation in reducing surface and subsurface inputs of phosphorus and nitrogen from farm fertilizers. The effectiveness of a perennial grass buffer strip, a forested buffer strip, and no buffer strip (crops planted to the stream bank) will be compared. Results will help in the evaluation of federal and state agricultural policies mandated by the Clean Water Act and in the restoration of Illinois streams.

Hybrid crappie as sport fish

D. Buck, M. Hooe

White and black crappie are popular sport fish but stocked in small impoundments, they tend to overpopulate, leading to stunting and severe competition with bass and bluegill. A study to determine if hybrid crappies might control overpopulation found that interspecific F_1 hybrids grew significantly faster than either parent species. Their reproductive potential was similar to that of the parent species and they had the potential to backcross with parent species. Recruitment levels, however, were lower than those of the parent species. Future studies will determine if hybrids can sustain desirable populations in impoundments with largemouth bass and bluegills.



Newton Lake oil spill four years later

L. Osborne, P. Tazik

From 1973 to 1984, between 9,000 and 12,000 oil pollution incidents occurred in U.S. waters. In April 1985, a pipeline ruptured spilling more than 10,700 barrels of Louisiana crude into Newton Lake, Illinois—the second largest inland oil spill in U.S. history. Four years later, Survey scientists were asked by Marathon Oil to assess the recovery of the bottom invertebrate fauna of Newton Lake. Samples are being collected from 20 locations in the lake over a three-year period. These data, in conjunction with pre-spill and initial impact data, will be used to predict the recovery time required by bottom fauna—an important link in aquatic food chains—following the accidental discharge of oil.

PIK programs and stream quality

B. Dickson, L. Osborne

Because of the importance of agriculture to the U.S. economy, numerous federal programs have been instituted to increase farm prices and improve the competitive ability of farmers. In general, however, these policies fail to consider environmental benefits that might simultaneously be gained through programs like cropland set-asides. Data from Soil Conservation Service files on the enrollment of farmers in PIK (payment in kind) programs in 12 Illinois watersheds will be compared with historical data on surface water quality to determine the effect of row crop reductions on stream quality. Ultimately, this study will assess potential environmental benefits of federal agriculture policies.

Sport fish forage

L. Osborne, P. Bayley, R. Larimore

Research has demonstrated that macroinvertebrates, particularly crayfish, and smaller forage fish make up the principal diet of most stream sport fish. Research is underway to assess the relationship between abundance of food and densities of sport fish. From an applied standpoint, attempts to restore stream systems to enhance fishing may prove useless if forage is inadequate. In addition, hatchery personnel need information on the carrying capacity of streams prior to stocking. From a more basic perspective, this study will provide information on predator-prey relationships in aquatic ecosystems, a finding that will aid in selecting systems most likely to benefit from restoration.

Streams and the 1988 drought

P. Bayley, L. Osborne, R. Larimore
In addition to disturbances caused by human activities, stream populations must withstand natural disturbances. The midwestern drought of 1988 provided an opportunity for aquatic biologists to examine the large-scale impact of drought on stream fish and macroinvertebrate populations. Under investigation is the recovery of sport fish and macroinvertebrates at four locations in Champaign County. Results should provide managers with a measure of the elasticity of sport fish populations following a natural disturbance. Further, the study is testing fundamental ecological paradigms regarding the recovery of disturbed ecosystems.

Downstream drift

S. Kohler, J. Allan
This research endeavors to clarify mechanisms responsible for the downstream drift of invertebrates and focuses on how animals enter the water column and drift downstream, whether drift entry is largely active or passive. This study is the first to demonstrate a link between competition, drift, and the population size of invertebrates in the field. Because many fish species feed largely on drifting invertebrates, understanding how and why animals drift has potentially important management implications. A time-lapse video system has been assembled to study the behavior of invertebrates during the day and night (using infrared illumination) in the field and laboratory.

Lake Michigan lake trout

J. Epifanio, D. Philipp
Invasion by the sea lamprey, over-harvest, and pollution were responsible for the extirpation of the lake trout of Lake Michigan in the 1960s. Since then, a major effort has been underway to reestablish a self-sustaining population through the introduction of hatchery fish. Over the years, several genetic stocks have been used as brood sources. Studies to determine which of these stocks contribute to natural reproduction are now beginning. Their objective is to develop a combination of molecular techniques that will identify the brood-stock heritage of lake trout.

Stocking largemouth bass

J. Claussen, D. Philipp
Illinois has a substantial north-south climatic gradient, and aquatic environments in the northern and southern parts of the State experience different selective pressures. Through natural selection, fish populations evolve local adaptations in response to these pressures. Experimental populations of genetically tagged stocks of largemouth bass, one from northern and one from southern Illinois, were established around the State. This study demonstrated that local adaptations give local stocks increased survival, growth, and reproductive traits. These results suggest that multiple brood stocks be established to produce largemouth bass suited for the specific geographic regions of the State.

Predators and benthic communities

S. Kohler, M. McPeck
Researchers are attempting to determine the role of fish predators in structuring benthic invertebrate communities in streams. Even without consuming them, fish have important effects on their invertebrate prey. Previous studies suggest that the presence of a common benthic-feeding fish may affect the behavior of one prey species but not that of its major competitor. Consequently, the research team predicts that the presence (or absence) of a shared predator will affect the outcome of competition between the invertebrate species on which that predator feeds. Preliminary experiments support this prediction, and future studies may document its generality.

Largemouth bass recruitment

D. Philipp, T. Churchill
Illinois Department of Conservation biologists noted that largemouth bass have recruitment problems in certain lakes in northern Illinois. Field sampling will identify the duration and success of spawning in seven lakes, and data on growth, survival, and spawning success will identify lakes with recruitment problems. The biological, climatic, and physicochemical parameters of the lakes will then be compared. Genetically tagged stocks of northern largemouth bass have been introduced to determine if a solution based on genetic correction is feasible. Finally, metabolic strategies of lake stocks will be compared with those of known stocks to determine physiological differences.

Genetics and walleye management

M. Jennings, D. Philipp
Walleye spawn on rocky-gravel shoals in lakes and on gravel beds in rivers. Ecologists speculate that these behaviors define two distinct stocks. In cooperation with fishery agencies in Iowa, Minnesota, and Illinois, Survey researchers constructed genetically tagged stocks of lake-spawning (Iowa) and river-spawning (Minnesota) walleye. These hatchery-raised fish were released as fry into two lake-river habitats. Survival, growth, and reproduction are now being monitored. In a second study, genetically tagged walleye were introduced into Illinois lakes as fry and as fingerlings. Stocking fry and 1- to 2-inch fingerlings proved successful; returns from 3- to 5-inch fingerlings were poor.

Competition and invertebrate communities

S. Kohler
The apparently disease-induced elimination of a dominant periphyton-grazing insect population in a stream created a natural experiment in which to study the structural and functional roles of a key species. Initial responses resembled those observed in earlier experimental studies. The effects of the removal of a key species, in this case an insect, is expected to travel up the food web and to be observed as increases in growth rates and/or population densities of invertebrate competitors and vertebrate predators. This research will provide important information regarding how a single dominant species can affect the structure and function of an entire ecosystem.

Introducing Florida largemouth bass

D. Philipp, G. Whitt, J. Claussen
Florida largemouth bass reach very large sizes—in Florida. This fact has lured state fishery agencies to introduce Florida subspecies well north of their native range. Genetically tagged stocks of Florida and northern (from Wisconsin) largemouth bass were used in laboratory and field experiments to demonstrate that the two subspecies are physiologically and genetically distinct. When the fish were introduced into natural environments in Illinois, the northern subspecies showed greater growth, survival, and reproductive success. Introgression caused by the introduction of the Florida subspecies could, therefore, drastically affect the performance and fitness of native stocks.

Local adaptation in largemouth bass

D. Philipp, J. Claussen

Evolutionary theory has it that through the process of natural selection each population of a given species undergoes local adaptation to its home environment in order to ensure the relative fitness of individuals. Based on this principle, researchers hypothesized that "foreign" stock of largemouth bass (stock produced from a source other than the home lake) would be less fit than resident stock. Genetically tagged stocks of largemouth bass from Wisconsin, Illinois, Texas, and Florida were used to establish experimental populations from Minnesota to Florida. In every case, local stock outperformed introduced stocks in survival, growth, and reproductive success.

Bluegill spawning dynamics

J. Claussen, M. Gross, D. Philipp

The bluegill population of Lake Opinicon, Ontario is the subject of an ongoing study. Each year from late May through mid-July, bluegill spawn in 4–6 distinct bouts. Parental males form colonies of 5–350 males at various depths and on various substrates. Mating success (eggs fertilized) and reproductive success (free-swimming fry produced) vary greatly among males in the same colony, in different colonies, and in different bouts, and analyses are underway to determine which factors contribute to success. Manipulations of food intake will test the hypothesis that a male's competitive ability and willingness to defend his brood is energy-limited, an important new concept in recruitment theory.

Sunfish mating systems

M. Jennings, D. Philipp

In contrast to the bluegill, which spawns almost exclusively in large colonies, and the pumpkinseed sunfish, which spawns almost exclusively as solitary males, the longear sunfish does both. Behavioral observation and molecular techniques are being used with natural and experimental populations to assess the relative mating and reproductive success of solitary and colonial male spawners. Although interspecific competition from rock bass and smallmouth bass early in the spawning season may affect a longear sunfish male's decision about how and where to spawn, the alternative tactics employed by subordinate males apparently affect the mating system as well.

Paddlefish genetics

J. Epifanio, M. Nedbal, D. Philipp

The paddlefish is a primitive, long-lived fish that inhabits large rivers, requires many years to reach sexual maturity, and needs gravel bars with minimal flow regimes to reproduce. Dams and impoundments have destroyed much of its spawning habitat, and efforts to save this fish must now rely on artificial propagation. Before guidelines for selecting brood stock can be written, data on the genetic structure of this species are needed. With the Missouri Department of Conservation and eleven other state and federal agencies, Survey researchers are analyzing populations of paddlefish across the U.S., relying on a combination of protein electrophoresis and mitochondria DNA analyses.

Bluegill reproductive behavior

P. Kindler, J. Bahr, D. Philipp

The bluegill with its two distinct male life histories (parental and cuckolder) is an ideal species for the study of reproductive behavior. Using radioimmunoassay procedures to quantify serum hormone levels, researchers demonstrated that 11-ketotestosterone is important for parental male behavior but not for cuckoldry; testosterone, however, appears to be important for both life histories. They postulate that 11-ketotestosterone is involved in competitively aggressive behavior among parental males during colony formation whereas testosterone is needed for sperm production. Field experiments coupled with behavioral observations are testing that hypothesis.

Speciation and gene divergence

J. Epifanio, D. Philipp

Speciation is a basic evolutionary process, but gaps remain in our understanding of how biological principles, particularly those at a molecular level, interact during this process. The sunfish family Centrarchidae is being studied because of the ease with which it hybridizes and because of the significant degrees of divergence at structural genes. Regulatory gene divergence is measured by assessing the degree of aberrant enzyme activity during embryogenesis of hybrids and by increases in the bilateral asymmetry of their morphological characters. Regulatory and structural gene divergences are now being compared within and among three species pairs and their hybrids in three genera.

Reproductive strategies in Fish

M. Gross, D. Philipp

Male bluegill enter one of two mutually exclusive life-history trajectories. Some delay maturation and spawn as parental males by building nests, courting females, and remaining to guard the offspring. Others, called cuckolders, mature at a much younger age and smaller size and "steal" fertilizations from spawning parental males by mimicking female behavior. *In vitro* crosses substantiated a genetic basis for these alternative life histories, and molecular genetic techniques documented successful fertilization by cuckolder males. Relying on behavioral observations and molecular genetic techniques, researchers hope to prove for the first time a major component of life-history theory.

Cuckoldry in interspecific hybridization

B. Konkle, D. Philipp

In Ontario's Lake Opinicon bluegill and pumpkinseed sunfish are about equally abundant, but 3–4% are hybrids between the two species. Using molecular genetic analyses, researchers found that F1 hybrids resulted from bluegill males mating with pumpkinseed females. Earlier work showed that the fitness of F₁ hybrids is much reduced; therefore, hybridization is a mistake for pumpkinseed females because they produce a limited number of gametes and for male bluegills because they exert considerable energy in parental care. Further studies will test the hypothesis that hybrids are primarily formed by bluegill cuckolders parasitizing spawning pumpkinseed pairs.

Environmental stress and genetic structure

C. O'Bara, D. Philipp

Certain kinds of environmental stress can cause the extirpation of a species from a water body either through acute mortalities or chronic reductions in reproductive success. What is unknown are the effects of sublethal environmental stress on genetic structure. In a survey of stream communities, researchers are using the Index of Biotic Integrity to classify the "ecological health" of a stream (and therefore its stress load). To assess chronic impacts on genetic structure, they are analyzing samples of two species of fish collected in streams that range from heavily impacted to nonimpacted. Genetic alterations may well serve as a mechanism for the early detection of stress in the environment.

Cost-effective toxicity tests

P. Ross, L. Burnett

Few toxicity tests can be implemented with small samples, low-cost testing periods, and high statistical reliability; yet these very characteristics are needed if a variety of environmental contaminants are to be monitored. A team of researchers have developed a toxicity testing battery that they hope will accommodate those requirements. Their six-test battery is currently being used to evaluate the toxicity of ten common waste disposal contaminants and will later be used on samples collected from waste disposal landfills.

Toxicity testing

P. Ross, L. Burnett

A battery of toxicity tests was developed and ten chemicals common to waste disposal sites—cadmium, copper, nickel, zinc, benzene, methoxychlor, pentachlorophenol, phenanthrene, phenol, and toluene—were used to evaluate the tests. The dose at which half of a test population was inhibited or killed was recorded for each chemical. With the exception of the extreme toxic response of a green alga to the metals, responses of all test organisms to all chemicals were similar. No single most sensitive or least sensitive species emerged, a finding that supports the growing belief among ecotoxicologists that more than one test must be used to determine the toxicity of a contaminated ecosystem.



Water quality criteria in Illinois

P. Ross, D. Zaber

The Illinois Pollution Control Board asked the Survey to provide a technical evaluation of the criteria proposed by the Illinois Environmental Protection Agency for chronic and acute toxicity, the methodology used to establish threshold criteria for water toxicity, the inadequacies of the proposed methodology for the control of water toxics, and a description of other methodologies that might be used where a proposed methodology was considered inadequate. A 73-page report covering these topics was presented at a hearing of the Illinois Pollution Control Board.

Contaminated sediment

P. Ross

The Water Quality Act of 1987 calls for a five-year study and demonstration program on methods to remove contaminated sediments from Great Lakes harbors. The Act specifies that the Ashtabula River, Ohio; the Buffalo River, New York; the Grand Calumet River, Indiana; Saginaw Bay, Michigan; and Sheboygan Harbor, Wisconsin, be given priority consideration for demonstration programs. A Survey aquatic ecologist is coordinating the toxicity investigations at these sites under a grant from the U.S. Environmental Protection Agency's Great Lake National Program Office in Chicago.

Toxic substances in the Illinois River

P. Ross, R. Sparks, F. Dillon, L. Burnett

By 1970, the standing crop of fish in the Illinois River was only 2% of what it had been in 1908, and diving ducks had virtually ceased to visit the river. Survey researchers demonstrated that a decline in the food supply (primarily fingernail clams, snails, and mayflies) on which fish and ducks fed was responsible. A toxic factor associated with sediments was suspected of keeping bottom-dwelling organisms from recolonizing the river. A project to identify this factor and its source established that sediments from the river are toxic to several standard reference species. One hypothesis suggests that unionized ammonia with a toxic contribution from hydrogen sulfide may be the toxic factor.

Mussel beds and sport fisheries

R. Sparks, P. Moy, R. Illyes

As larvae, the 78 species of Illinois mussels are parasitic on fish, using them for food and dispersal. Since the probability of random encounters between fish and mussels ready to release larvae is low, fish are probably attracted to mussels at the appropriate time. Bluegill and white crappie, for example, are attracted to mussels fresh from the river and consume the small invertebrates that colonize their shells. They also consume packets of larvae expelled by mussels. If mussels provide a solid substrate for invertebrates in streams otherwise dominated by shifting substrates and prove to be a significant food source for fish, the preservation of mussel beds is crucial.

Channel catfish and barge traffic

R. Sparks, B. Todd, F. Dillon

Channel catfish is a premium commercial fish in Illinois, but little is known about the effects of boat traffic on its seasonal habitat preferences in floodplain rivers. Radio-tagged catfish were observed moving into backwaters along the Illinois River whenever depths were more than 1.5 feet and water levels were high enough to provide access. So few fish occupied the main channel during the passage of barges that no conclusions could be drawn; however, injured and disoriented flathead catfish and gizzard shad were observed in the wake of towboats. Catfish had a clear preference for side channels and backwaters, and the fishery could be improved by rehabilitating these sediment-choked habitats.

Barge fleeing and mussel beds

R. Sparks, K. Blodgett

Barge fleeing areas and mussel beds tend to overlap in large rivers because both require sites with little sedimentation. Researchers found that if barges were moored in deep water instead of tying them off to shore, shell damage was prevented, although the fastest-growing species, the fragile papershell, showed slower shell growth in the mooring area than in other areas and several abundant species showed poor recruitment. Clearly, mussel beds require protection from disturbance by commercial and pleasure boats. Population data are needed for several species of mussels to determine the levels of survival, growth, and reproduction necessary to sustain native populations.

Mussel die-offs in the Mississippi River

R. Sparks, K. Blodgett

This project began in 1986 in response to massive die-offs (30–40% mortality) of mussels in the Mississippi River from 1982 to 1986. Because no mussel die-offs occurred during the project, investigators were unable to conduct infectivity studies to determine whether the cause was biological in origin. They did, however, identify 37 types of bacteria in mussels obtained from the Illinois and Mississippi rivers. That information forms a baseline for comparisons should mussel die-offs resume in the future.

Aquatic plant investigations

P. Tazik, V. Carter

In 1986, the U.S. Geological Survey initiated the National Water Quality Assessment Program to describe current water quality for U.S. surface- and groundwater resources, to define past trends and evaluate future ones, and to relate trends in water quality to natural factors, land use, and waste management. The Upper Illinois River Basin was included in this program because of its diverse land uses. In 1989, researchers conducted a preliminary survey of aquatic macrophyte populations at Illinois River study sites and at the Illinois Environmental Protection Agency's water quality sites. These data will be used to select sites for more detailed investigations.

Reservoir shad

D. Wahl, M. Mounce

Young-of-the-year gizzard shad are the dominant forage for most piscivorous fishes in Lake Shelbyville and other Illinois impoundments. Despite its importance as prey for sport fishes, little is known about the growth and survival of juvenile shad. A variety of physical and biological factors influence population dynamics, including zooplankton density, larval fish density, water temperature, adult spawning success, and predators. The relative importance of each in determining growth and survival of young-of-the-year is under investigation. The data generated will be used to develop management strategies to ensure the production of gizzard shad as well as predator populations.

Long-term river research

J. Grubaugh

Long-term data sets on the Illinois and Mississippi rivers are being organized and computerized. Over one hundred years of water level and discharge data from the Survey, the U.S. Army Corps of Engineers, the U.S. Geological Survey, and several municipalities are being compiled into a data set. A 30-year data set on fish populations in the Illinois and a 17-year set on invertebrates in the Keokuk Pool of the Mississippi will also be entered and verified. These data sets will constitute an important information resource for the future.

Aquatic vegetation in Pool 19

P. Tazik, R. Anderson

Since the construction in 1913 of Lock and Dam 19, the pool of impounded water has decreased in depth due to sedimentation. Within 40 years, bottom sediments reached the photic zone, allowing the growth of aquatic vegetation. The first estimates of vegetation cover in Pool 19 were made in the mid-1960s, and later surveys have shown dramatic increases in aquatic plant populations. Aerial photographs have also been used to estimate coverage, and in 1986 standing crop biomass was estimated for abundant species. During 1988, production data for *Vallisneria americana*, one of the dominant species in the pool, were collected.

Land-use and fish abundance

L. Osborne, P. Bayley, R. Larimore

To protect the integrity of stream communities, environmental planners and legislators must recognize the consequences to aquatic communities of land-use modifications in watersheds. Using aerial photographs in conjunction with the ARC/INFO geographic information system, researchers are examining land-use patterns in relation to the structure of fish communities in five Champaign County watersheds. Maps of historical land use were digitized so that comparisons can be made with current data. This information will be used to assess changes over the past thirty years and to predict long-term consequences of land-use modifications on fish communities.

Riverine vegetation in Pool 26

P. Tazik, R. Anderson

As part of the Upper Mississippi River Long-term Resource Monitoring Program, researchers are analyzing significant resource problems; monitoring selected pools to define long-term rate, direction, and extent of changes in fish and wildlife habitats; and developing data management systems and techniques to aid in river management. In 1989, studies included qualitative mapping of lowland and aquatic vegetation along selected transects, transfer of groundtruth and qualitative information to maps for digitizing and entry into the CRIC system, and preparation of voucher specimens.

Clipping for cattail control

P. Tazik

Cattails are a serious problem in ponds at the Natural Resources Studies Annex. Because these ponds contain experimental fish populations, chemical control is not an option. Pulling cattails is labor intensive and relatively ineffective. In 1988 the effectiveness of controlling cattails by cutting was investigated. In June all cattails in three ponds were cut at the sediment surface. Clipping continued throughout the summer to ensure that plants never reached the water surface. Plants decayed quickly and were maintained at acceptable levels. Clipping is less laborious than pulling and eliminates the chemical risk; however, it requires careful monitoring, especially during the first growing season.

Walleye survival and growth

D. Wahl, F. Santucci, Jr.

A study is in progress to compare survival and growth of small (mean = 60 mm), medium (mean = 135 mm), and large (mean = 208 mm) walleye stocked in Ridge Lake, a centrarchid-dominated impoundment. Fall population estimates indicated that large fingerlings had the highest survival rate, followed by medium fingerlings. No small walleye were recovered in extensive field sampling, a finding that suggests they suffered 100% mortality. In Ridge Lake, walleye primarily consumed bluegill, and annual growth increments were moderate compared with the growth rate of systems that contained such alternate prey as gizzard shad or cyprinids.



BOTANY AND PLANT PATHOLOGY

Anton G. Endress, Head

The mission of the Section of Botany and Plant Pathology is to discover new information about the plants of Illinois and to apply existing knowledge about them in new ways. Included in this study of plants are their diseases; the habitats, ecosystems, and landscape that support them; and the human activities that affect them.

Public Service

To be truly effective, the results of research studies and the management recommendations based on those results must be conveyed to homeowners, municipalities, professional groups, and other public and private agencies. Only through an active partnership between scientists and these groups can the intelligent development, maintenance, and conservation of the vegetation of the State be ensured.

That partnership was demonstrated in the more than 600 inquiries received concerning tree and shrub diseases, plant maintenance, the selection of tree cultivars, the identification of mushrooms and plants, prairie restoration, and the selection of species for revegetating highly disturbed lands. Over 250 diseased specimens of trees and other plants were received for laboratory diagnosis from foresters, farm advisors, and homeowners; approximately 200 on-site examinations were made for commercial and city arborists, extension staff, conservation managers, and homeowners. The long-term consequences of the drought on the health and longevity of trees, shrubs, and native wildflowers and grasses were of particular concern to many callers during the late summer and fall of 1988. By spring 1989, the subject of most inquiries had shifted to two tree diseases that had become unusually severe, perhaps because of last year's drought: scab on crabapple and anthracnose on sycamore.

With the completion of basic data entry and the release of a user's guide, use of the Illinois Plant Information Network (ILPIN) increased dramatically. ILPIN, a computerized collection of information about the vascular plants of Illinois, was developed by Dr. Louis Iverson with funding from the Illinois

Department of Transportation. Managed by Mr. David Ketzner, ILPIN includes information on taxonomy, distribution, biology, ecology, wildlife and livestock relationships, functional and structural relationships, status, human impact, revegetation and management, natural community preferences, and documentation references. A number of citizens and several state agencies used ILPIN during the year, with major requests for information from personnel at the Department of Transportation, the Department of Conservation, and the Chicago Botanic Garden and from other staff members at the Illinois Natural History Survey.

Botanists responded to the much discussed lack of scientific literacy among American youth in a direct and positive manner by establishing a working relationship with the elementary teachers of Champaign's public schools. Teachers and members of the staff are working together to develop dynamic and scientifically accurate curricular materials for classroom use. The first science units will be tested in classrooms during the 1989-1990 school year. Each unit draws heavily on the scientific expertise of the Section, and whenever possible scientific concepts are illustrated with examples drawn from central Illinois. The staff of the Section of Botany and Plant Pathology have also participated in public education activities by contributing information at workshops for science teachers, by judging projects at science fairs, by presenting talks in classrooms and school assemblies, and by serving as sources of scientific expertise that teachers may call upon.

As a consequence of above-average temperature, widespread drought, and elevated levels of air pollutants in 1988, regional electric consumption set new high records, water was rationed in many areas, and the nation's grain harvest fell below consumption for the first time in several years. These and similar events were widely reported by the media as scary consequences of a major climate change attributed to a greenhouse effect.

Global climate patterns and the greenhouse effect remain lively issues because of the possible implications for agriculture and food production in Illinois and because of their impact on the abundance, distribution, and vitality of the State's living organisms. In the past year, several research efforts focused on the consequences to organisms of changes in the quality of the environment. Studies centered on drought-related stress and the consequences of ozone pollution on native and economically important plant species. Reforestation, particularly in urban areas, was also investigated as a means of reducing the greenhouse effect.

Tree planting campaigns are being vigorously promoted because trees can reduce the amount of carbon dioxide released to the atmosphere, offsetting emissions from the burning of fossil fuel and slowing climate change from the

greenhouse effect. Over the past year, members of the Section made a concerted effort to aid and promote the several reforestation and environmental planning programs that will be highly visible and important statewide initiatives during the next few years. Major elements of this effort included the development of specific information for the Governor's Office and others concerning the selection and planting of appropriate tree species or cultivars at sites where they can prosper, the initiation of study to determine the feasibility of integrating cultivar-specific information with the multi-decade Illinois weather data set to generate an Illinois-specific vegetation hardiness map, and the initiation of a project to characterize the urban landscape of forty municipalities within the greater Chicago metropolitan area and to identify the spatial and temporal changes in the patterns of its use. Eighty-three percent of

the citizens of the State live in urban areas, and Illinois ranks 47th among states in public land open space per capita. For many, urban forests and other urban space may be their only exposure to the natural world.

Special Recognition

In August of 1988, Dr. Louis Iverson presented a paper, co-authored by Ms. Elizabeth Cook, entitled "Interpreting Forest Biome Productivity and Cover Utilizing Nested Scales of Image Resolution and Biogeographical Analysis," at the Final Thematic Mapper Workshop at the University of Maryland, College Park. Their project was well received by NASA representatives and the thirty-five assembled principal investigators. After review, their research received top ratings and was cited for "new and innovative use of the technology."

Research Reports

The pages that follow summarize the research activities underway in the Section of Botany and Plant Pathology during the past fiscal year. Their range is varied and their practical applications apparent. Of special interest to readers concerned with environmental issues are the compensatory mechanism of a radish cultivar to ozone stress and the improved performance of a nonnative weed species to increasing concentrations of ozone.



Leptosphaeria monograph

J. Crane
Leptosphaeria (fungi) contains a large number of biologically important and diverse species and is in need of taxonomic revision. New descriptions and illustrations of each of these species are being prepared. The monograph that will result from this study will be a significant publication because it will permit the correct application of a name and the correct identification of the causal agents of many plant and animal diseases, including species found on crop plants.

Diversity in tree selection

A. Endress, R. Neely, D. Schoeneweiss
Concern about the greenhouse effect, habitat fragmentation, and loss of biodiversity has generated new interest in tree planting. Selecting appropriate species and locating them where they can prosper is essential if the dangers of unplanned reforestation are to be avoided. Species uniformity, for example, leaves the newly forested landscape highly vulnerable and must be avoided as must the costs of caring for and perhaps replacing trees planted at locations for which they were not adapted. Research and management expertise must be available at the community level if tree planting campaigns are to succeed.

Assessing land cover in Illinois

L. Iverson, E. Cook
Current land cover and land-cover changes for the Chicago metropolitan region and several communities of east-central Illinois are being assessed with satellite imagery and geographic information system techniques. Emphasis is on identifying urban forestland and the rate of change in these and other vegetated open spaces. This land-cover information will be correlated to water quality within watersheds and to various economic and social variables in order to evaluate the importance of forests and grasslands to the overall quality of life in urban areas.

Environmental impacts on native grasses

A. Endress, L. Iverson
The recent co-occurrence of periods of drought with increased ozone pollution may seriously diminish the ability of native species to prosper. The intra- and interspecific competitive abilities of big bluestem, Indian grass, and giant foxtail were studied in response to ozone and drought stresses, singly and combined. Responses were complex and varied according to severity of stress, particular species mixture, and relative proportion of each species. Interestingly, the performance of the nonnative weed species (giant foxtail) was stimulated by increasing ozone concentrations.

Drought and crop photosynthesis

C. Grunwald
When water is in short supply, reduced growth and decreased numbers of flowers and seeds are the aspects of plant development most visibly affected. Research focused on the critical function of photosynthesis, but not all plants responded to the same degree. At a given stress level, net photosynthesis in corn was inhibited by 75% but only by 40% in soybean. The relationship between lowered plant weight and yield was unclear. Yield seemed to be determined more by total photosynthesis over the entire growing season than by that which occurred only during the drought-sensitive seed-filling period.

Plants in oil field soils

L. Iverson, D. Ketzner
A test plot was established in 1986 near Flora in Clay County, Illinois, to assess the capacity of 17 plant species to withstand salty conditions on brine-contaminated soils. After three growing seasons, the most successful species were tall wheatgrass (*Agropyron elongatum*) and the four-winged saltbush (*Atriplex canescens*). Additional seedings and treatments were established in 1987 on a barren area surrounding the test plot. Results proved inconclusive because of excessively dry conditions; however, tall wheatgrass established over much of the area.



Leafless sycamores

R. Neely
Many sycamore trees in Illinois were leafless during the early growing season in 1989. Only after mid-June did these trees begin to establish a full crown of leaves. This condition was the result of weather that favored anthracnose, a fungus disease of sycamores. The fungus and not the tree is vigorous during extended cool periods in late fall and early spring. Plant pathologists are seeking environmentally acceptable methods of controlling the disease. A trunk injection that eliminates the need for foliar sprays has been successful in field trials for two to three years.

Dutch elm disease in Chicago

D. Neely

Illinois is the only state where a number of cities have kept Dutch elm disease losses to a relatively low rate. These cities attempted to maintain elm population while replacing lost elms with tree species not susceptible to disease. Control was based on the prompt removal of diseased trees. When the control area was as large as a city, the measure proved successful. Plant pathologists have evaluated the success of those efforts for 35 years and found that most elms in 20 cities that practiced control were retained whereas elms in other cities had been lost by 1970. Cities with the will found the way.



Tubakia leaf spot on oak

D. Neely

Oaks are highly regarded as an amenity tree. They function well in cities and in forests, but a disease that can cause premature defoliation of oak leaves in August or September has been observed in central and northern Illinois. Plant pathologists in the Section have observed, described, and established the cause of the disease—the fungus *Tubakia dryina*. Because the disease is more severe on stressed than on nonstressed trees, maintaining the vigor of oaks through fertilization, watering, and mulching should reduce the incidence of the disease.

Generic limits and evolution in Maloideae

K. Robertson

Scientists disagree about the number of genera in the Maloideae group of the rose family; some say fewer than 10, others say more than 30 genera. This study strives to formulate a system of classification that reflects both phenetic divergence and cladistic relationships and to develop hypotheses of evolutionary history. A suite of morphological characters for 150 species, representing the taxonomic and geographical diversity of the nearly 1,000 species of Maloideae, has been analyzed by cladistic and phenetic methods.

Illinois Plant Information Network

L. Iverson, D. Ketzner

The Illinois Plant Information Network (ILPIN), a computerized catalog of information on the vascular flora of Illinois, presents data in such categories as species taxonomy and distribution as well as providing material on wildlife and livestock relationships, human impacts, and natural community preference. References for each species are also given. Data entry for all Illinois species has been completed, and the value of ILPIN is already established with recent requests for information from the Department of Transportation, the Department of Conservation, and the Chicago Botanic Garden.

Canker on honeylocust

D. Neely

Honeylocust has been used extensively in Illinois as a replacement for elms lost to Dutch elm disease. Many of these trees are now 30 years old and have been observed to decline and die in urban sites. One cause of the decline is the incidence of a canker caused by the fungus *Thyronectria austro-americana*. Plant pathologists in the Section have assessed the severity of the disease on six cultivars of honeylocust and found that cankers were least frequent on 'Imperial', 'Holka', and 'Shademaster'. These disease-resistant cultivars should be emphasized in landscape plans.

Getting used to air pollutants

A. Endress, S. Post

Sustaining food production in the face of an uncertain climate and deteriorating air quality is a subject of considerable importance, and past research with soybeans has been broadened to include vegetables. The radish cultivar 'Cherry Belle' proved not as sensitive to ozone as previously believed. It compensates for ozone stress by developing larger leaves that are more ozone-resistant. Studies are under way to define this compensatory mechanism more fully and to determine whether it is common to other plant species.



ECONOMIC ENTOMOLOGY

William G. Ruesink, Head

The mission of the Section of Economic Entomology is to discover and develop methods for protecting agricultural crops, forests, and ornamental plants, as well as humans and domestic animals, from injury by insects, mites, ticks, and vector-borne diseases.

The Section is composed of research entomologists, extension specialists, and supporting personnel funded by the Illinois Natural History Survey and the College of Agriculture of the University of Illinois at Urbana-Champaign. Since 1885, these two institutional units have collaborated to meet the entomological needs of the agricultural community and to serve the citizens of the State.

Public Service

The majority of public service activities were organized and led by Extension entomologists. These activities included writing (in collaboration with other specialists at the University of Illinois) three newsletters that were distributed to over 4,000 people during 1989. The *Home, Yard & Garden Pest Newsletter* is published weekly (20 issues) during the summer. *Insect, Weed & Plant Disease Survey Bulletin* follows the same summer schedule and in addition is published twice during the winter. *Illinois Spray Service Report* serves the commercial fruit-growing industry and is issued 17 times during the growing season. Extension entomologists also completed the revision of circulars on insect pest management in four areas: commercial vegetable crops, livestock and livestock buildings, field and forage crops, and home, yard and garden. These guides note which insect pests are expected to be most important during the coming year and suggest how to avoid or mitigate the problems they cause.

Each year the Section organizes five multidisciplinary educational programs with an attendance of about 1,500. These are one-to-three-day meetings for such interested parties as farmers, farm managers, fertilizer and pesticide dealers, crop consultants, and

custom pesticide applicators and cover topics that range from how to identify pests to perspectives on environmental issues. Proceedings are published for two of these programs: the Crop Protection Workshop and the Agricultural Pesticides Conference.

Other educational programs take entomologists into fields and meetinghouses across the State. During the past year, Section staff participated in over 100 such efforts, including "agronomy day" programs, winter tillage workshops, pesticide applicator training clinics, seed clinics, master gardener training, a workshop on greenhouse insects, and the Illinois Fruit and Vegetable School. Research scientists gave additional talks on their specialties to such groups as the Mid-America and Illinois Christmas Tree Growers, the Professional Crop Consultants of Illinois, the Illinois Environmental Health Association, the Illinois Science Teachers Convention, the Illinois Native Plant Society, and the Sierra Club.

On 15 June 1989, over 200 people attended the first-ever Agricultural Entomology Field Day at the Section's research plots in Champaign. Visitors saw insect pests and insect damage just as farmers would see them in their fields. They also heard firsthand reports on current research, with emphasis on developments in biological control.

Several displays were prepared and shown by research scientists, with topics ranging from "Insects of Illinois Trees and Shrubs" shown at the State Fair to samples from the Survey insect collection shown at the Boy Scout Camporee at Clinton Lake.

Service at a more personal level was rendered by scientists who judged entries at local science fairs or insect collections at the State Fair, who gave lectures in courses at the University of Illinois, who served on the advisory committees of graduate students, who identified insects and ticks for individual citizens, and who served as members or advisors for such groups as the Illinois Nature

Preserves Commission, the Illinois Ground-water Technical Standards Advisory Committee, and the Grand Prairie Friends of Illinois.

During the past year much concern was expressed over mosquitoes reproducing in abandoned tires. Scientists from Economic Entomology provided counsel to the City of Chicago on methods of controlling tire-inhabiting mosquitoes and technical information on the biology and control of these mosquitoes to the Illinois Pollution Control Board and the Governor's committee that wrote the 1989 Waste Tire Legislation. They also assisted in delimiting the distribution of the Asian tiger mosquito in Chicago and East St. Louis.

Special Recognition

Members of the Section of Economic Entomology strive for excellence in every aspect of their work. By and large, their greatest reward is the joy that comes from discovering new facts, unraveling the mysteries of nature, and conveying this new information to others. Occasionally, as a byproduct of scientific success, a scientist earns the additional pleasure of an honor bestowed by peers. During the past year, the Section has received several of these pleasant surprises.

The *World Bibliography of Soybean Entomology*, a two-volume work by a team of entomologists, librarian, and computer scientist—Ms. Jenny Kogan, Dr. Marcos Kogan, Mr. Charles G. Helm, and Ms. Ellen F. Brewer—won the 1989 Oberly Award for Bibliographic Excellence in Agricultural and Related Sciences, an award given by the American Library Association. The bibliography represents twenty years of effort in acquiring and electronically indexing the world's literature on insects of soybeans. Six detailed indexes provide superb guidance to the more than 5,000 entries in 24 languages from 87 countries.

Extension entomologist Kevin L. Steffey was the 1989 recipient of the Young Faculty Award for Excellence in Extension from the College of Agriculture at the University of Illinois. This award is given for "outstanding professional achievement and demonstrated excellence." In granting this award, the University wrote, Dr. Steffey "has demonstrated excellence in all aspects of Extension education, including field demonstration/

research trials, county and area meetings, statewide conferences, and written educational material." To cite only one example, since 1980 Dr. Steffey has carried out insect management tests with nearly 150 farmer cooperators in 55 counties.

Extension entomologist Donald E. Kuhlman, who has been with the Section since 1966, was selected by the University of Illinois for its newly created position of Program Leader for Environmental Issues. While working with the entomology program at the Survey, Dr. Kuhlman became a leading spokesman for the safe use of insecticides. In recent years his interests and expertise broadened to include agricultural chemicals other than insecticides. The University recognized his value to newly emerging programs and created a position that will provide Dr. Kuhlman with greater opportunities to reduce the environmental damage caused by agricultural chemicals and practices.

Research entomologist Michael E. Irwin has been appointed to a five-year term as Deputy Executive Director of the Consortium for International Crop Protection. This consortium of universities serves as a clearing house and management center for projects working to improve pest management in developing nations throughout the world.

The value of a scientific organization is measured in large part by the strength of its publications activities. The vitality of the Section can be seen in the number of scientists who have been asked to serve as editors or on editorial boards and committees: Dr. James E. Appleby is editor of *Illinois Arboriculture* and

serves on the editorial board of the *Journal of Arboriculture*, Dr. Marcos Kogan is on the editorial boards of *Entomologia Experimentalis et Applicata* and *Miscellaneous Publications of the Entomological Society of America*, Dr. Michael E. Irwin serves on the editorial board of the *Bulletin of the Entomological Society of America*, Dr. Catherine E. Eastman is a member of the editorial board of the *Journal of Economic Entomology*, and Mr. John K. Bouseman was a member of the search committee for editor of the *Coleopterists Bulletin*.

Section scientists have also served in other highly responsible capacities for national and regional organizations. Perhaps most notable of these is Dr. Catherine E. Eastman, serving her second three-year term as representative from the 9,000 member Entomological Society of America to the American Association for the Advancement of Science. On a regional level, Dr. William G. Ruesink was program chair for the 1989 meetings of the North Central Branch of the Entomological Society of America, and Dr. Kevin L. Steffey is chair of its ad hoc Public Information/Public Relations Committee.

And, finally, Section scientists are often invited to speak to gatherings of other scientists, but only occasionally is one invited to an especially prestigious forum. During the past year, two such invitations were received. In February, Dr. Michael E. Irwin delivered a paper on ecological niches occupied by thrips at the International Conference on Thrips in Burlington, Vermont; in April, Dr. Marcos Kogan spoke on integrated pest management of soybeans as part of the Distinguished Lecturer Series at Texas A&M University.

Research Reports

The nearly sixty research summaries that follow make clear the value of the Section of Economic Entomology to the agricultural community of Illinois—from soybean and corn farmers to horseradish and pumpkin growers. Of interest to all Illinoisians, whether urban or rural residents, are the many studies that look to biological pest control and the reduction of pesticides in the soils and streams of the State.



Asian tiger mosquito

R. Novak, B. Steinly, D. Webb
The Asian tiger mosquito, *Aedes Albopictus*, is presently found in significant numbers within two Illinois cities, Chicago and East St. Louis. Since this highly domestic mosquito is capable of carrying 26 known viruses that affect man, as well as dog heart-worm, the assessment of its spread is essential. Information from this study will be used to develop control strategies to inhibit its rapid spread and to reduce its numbers in congested urban areas. In addition, this study will provide data on the number, density, and primary habitats of other important mosquitoes found in urban environments.

Culex in an urban environment

B. Steinly, N. Iannone, R. Novak
Researchers evaluated the Champaign-Urbana-University of Illinois Vector Control Program by placing containers for egg laying by *Culex* mosquitoes at a variety of locations throughout the Twin Cities and the Campus. The contents of these containers were sampled daily. Information from this surveillance was used to determine the success of the control program and to identify areas where increased control was warranted. Entomological and logistical information from this study will be used to develop criteria for similar programs throughout the State.

Mosquito resistance to insecticides

R. Metcalf, R. Novak, R. Lampman
Studies are underway to determine the number of generations required by mosquitoes to establish resistance to chemical and bacteriological insecticides. Populations of *Aedes albopictus* and other container-inhabiting mosquitoes from Illinois and adjacent states will be evaluated for current levels of resistance. That information will be used to develop control programs that will inhibit or prevent the development of resistance. In addition, insight into the biological processes that cause this resistance will be gained.

Alternatives to chemical controls

R. Novak, R. Metcalf, R. Lampman
Container-inhabiting mosquitoes frequent the homes and yards of urban dwellers. This study tests and evaluates several products commonly found in homes, products that can safely be used to control these mosquitoes. In addition, this study will make available information that can be used by homeowners to prevent mosquitoes from breeding on their premises.

Aedes triseriatus in an urban environment

R. Novak, B. Steinly, R. Milton
Aedes triseriatus, a container-inhabiting mosquito that breeds in tree holes and tires, is the primary carrier in Illinois of LaCrosse Encephalitis virus, a suburban-rural disease that has recently been isolated in urban environments. Information collected to date shows that significant populations are now indigenous to urban areas, especially older sections of cities. Results of this study will help to devise a predictive model of disease transmission in cities so that environmentally safe control strategies can be developed.

Epidemiology of insect diseases

D. Onstad, J. Maddox
To study mechanisms leading to epidemics, a complex mathematical model of the European corn borer, a pest of corn, and its naturally occurring disease caused by *Nosema pyrausta* was computed on the Cray X/MP-48 supercomputer at the National Center for Supercomputing Applications. Results demonstrated that a traditional theory in epidemiology is too simple to explain the epidemics in complex natural systems.



Container-inhabiting mosquitoes

R. Novak, G. Craig, Jr., B. Steinly
The arrival of the Asian tiger mosquito in Illinois has generated considerable interest in container-inhabiting mosquitoes. The aquatic larval and adult populations of *Aedes albopictus*, *Ae. triseriatus*, *Culex pipiens* and *Cx. restuans* are being examined in artificial settings (tires) and natural sites (tree rot holes) at several locations in Illinois and adjacent states. The four species carry microbes that affect man, and this study is designed to identify environmental characteristics that play important roles in the transmission and maintenance of these microbes.

Suppression of flour beetles

D. Onstad, J. Maddox

A detailed mathematical model of the confused flour beetle, a pest of stored grain products, and its pathogen, *Nosema whitei*, was computed on the Cray X/MP-48 supercomputer at the National Center for Supercomputing Applications to determine the effect of the disease on population density over time. Results indicated that the disease can suppress beetles to a density that is 90% below the density of disease-free populations. This finding is an initial step in understanding the ecology of this pest.

Alfalfa weevil: old pest, new solution?

S. Roberts, A. Kirts, E. Armbrust, J. Maddox

Alfalfa weevils are destructive to first-crop alfalfa, and control traditionally required an insecticide often sprayed more than once a year. In recent years, parasites have become established and have helped to control the pest naturally. Now a fungal pathogen shows promise for controlling this serious pest. Efforts currently center on the collection of biological material for laboratory studies to develop ways of producing this fungus in quantities that will allow its use as a biological control agent. Applications of this pathogen would be safe because it is not harmful to humans, animals, or other parasites or predators.

Corn-growing subregions in the Midwest

M. McGiffen, W. Ruesink

A statistical analysis divided the Midwest into six subregions—clusters of counties with similar corn production characteristics. April and July temperature and precipitation, soil characteristics, acreage planted, and yield were considered. The northern two-thirds of Illinois fall into the prime corn-growing subregion. Counties in southern Illinois have characteristics more typical of the Southeast than the Midwest. This analysis is part of a regional project to set priorities for research in corn pest management and illustrates why field studies must be replicated in various growing regions.

Timing of disease processes

D. Onstad, J. Maddox, L. Solter

The timing of events in the life cycle of the European corn borer can be important in the transmission and spread of a chronic disease caused by a protozoan. Two experiments investigated the dynamics of this disease. In the first, development times of diseased borers proved significantly slower than those of healthy borers at average summer temperatures in Illinois. In the second, the production of infective spores by the pathogen increased as the insect pest grew older. This information will ultimately prove useful in the control of this pest.

Potato leafhopper control

E. Armbrust, S. Roberts, M. Morris

Oaks, maples, apple orchards, grasses, weeds, and clover were sampled to determine the types of leafhoppers present after their spring migration from southern states. The potato leafhopper was the most abundant, and these plants may therefore be serving as a source of adult leafhoppers for adjacent alfalfa fields. By monitoring neighboring plants, entomologists may be able to forecast damaging populations on alfalfa. By controlling leafhoppers on nonagricultural plants, farmers may be able to reduce the pesticides used on food crops.

Phylogeny of microsporidia

C. Vossbrinck, M. Baker, B. Debrunner-Vossbrinck, J. Maddox

Members of the phylum Microsporidia, the oldest known group of eukaryotic organisms, are parasites of every animal phylum. Although 1,500 species have been described, several million undescribed species undoubtedly exist. The classification of the microsporidia is in disarray, largely because no one knows which taxonomic characters are primitive or the phylogenetic relationships of the microsporidian genera. Survey scientists have sequenced rRNA from 17 species of six genera in an effort to determine generic relationships and the relationships of taxonomic characters.

Modes of disease transmission

D. Onstad, J. Maddox, L. Solter

A protozoan disease of the European corn borer is known to be transmitted from one immature insect to another by feeding on infective spores or by being transmitted congenitally from female to offspring. Research is in progress to determine if the spread of this disease is complicated by other modes of transmission such as feeding by adult corn borers or venereally from infected males to uninfected females. Results may help to understand why epidemics occur in populations of this serious pest of corn.

Fungus reduces potato leafhopper

S. Roberts, A. Kirts, J. Maddox, E. Armbrust

The potato leafhopper, a serious pest of alfalfa and other crops, feeds by piercing the plant and sucking out its juices, thereby stunting the plant and causing it to yellow. Research currently focuses on a naturally occurring fungal pathogen that reduces potato leafhopper populations. This pathogen is harmless to humans and animals, can be manipulated by artificial introduction, and may help to reduce the applications of pesticides now required to control potato leafhoppers in Illinois.

Gypsy moth microsporidia

J. Maddox, M. Jeffords

Some microsporidia are important naturally occurring biological control agents of the gypsy moth. Researchers obtained several species of microsporidia from Eurasia, the native home of the gypsy moth, and introduced them into experimental populations of gypsy moths. Prior to widespread introductions, however, extensive information must be provided to regulatory authorities. The generic placement of the microsporidia is an important issue, and researchers are determining the life cycles and ultrastructural characteristics of these species in order to place them in the correct genus.

Oviposition behavior of *Culex*

B. Steinly, R. Novak
This study is designed to determine a sampling procedure that can be used to characterize the egg-laying preferences of *Culex* (*Culex*) in urban environments. Two aspects of the oviposition environment have been examined: color of the container for egg laying (ovitrap) and water quality of the egg-laying surface. Three of the *Culex* species studied are considered primary carriers of St. Louis Encephalitis Virus, a severe disease of man. Information from this research will be used to develop a model capable of predicting outbreaks of this disease in Illinois.

Introduction of gypsy moth microsporidia

M. Jeffords, B. Dhar, J. Maddox
Microsporidia, protozoanlike pathogens of invertebrates, are important naturally occurring biological control agents of many insects. Several are known to control the gypsy moth in its native home, Eurasia. These microsporidia do not occur in the U.S., and researchers have used an egg contamination method to introduce five species into experimental gypsy moth populations. Four of the five species have persisted over at least one winter, and one has persisted for three years in the same location.

Spiroplasma and leafhopper longevity

C. Eastman, H. Oloumi-Sadeghi
Studies of the effects of a plant-pathogenic spiroplasma on the longevity of its primary insect vector and alternate host—the beet leafhopper—were concluded during the year. Infected leafhoppers lived almost as long as healthy leafhoppers, and some were able to transmit spiroplasmas to test plants until death. This finding lends support to the view that the “successful” plant pathogens among those that multiply in their vectors may have co-evolved with their primary vectors to the extent that the possible harmful aspects of this pathogen-insect vector relationship are minimized.

Pod feeding by bean leaf beetles

M. Kogan, C. Helu, D. Buchori
Second-generation bean leaf beetles are known to injure soybean pods late in the season, scarring pod walls and thereby facilitating the entrance of fungal spores into the pod interior and the developing seeds. Ten species of fungi generally innocuous to soybeans were associated with seeds in scarred pods. Studies indicate that seed injury is most intense when scarring occurs early in pod development and increases with the increase of bean leaf beetle populations. Detailed mappings of pod injury show that pods developing in the upper third of plants suffer most from scarring. These data are essential in defining economic injury levels for soybeans.

A microsporidium of flies

S. Lanka, J. Maddox
The microsporidium *Octosporea muscaedomesticae* infects a range of fly species, including blowflies and syrphid flies. Its effect on field populations is not known, but it is a major problem in laboratory colonies. Several strains exist, and they behave differently in different host species. The effects of different isolates of this pathogen on host flies other than the host from which they were isolated are being studied because host-pathogen relationships differ significantly when cross transmissions occur. Microsporidia may even become new species by invading new hosts and then becoming isolated, and an attempt will be made to verify this hypothesis.

Horseradish susceptibility to infection

C. Eastman
Greenhouse trials evaluated the susceptibility of Illinois horseradish cultivars to infection by the brittle root spiroplasma, believed to be transmitted primarily by the beet leafhopper. Preliminary results indicate differences in susceptibility among Commons, Swiss, and Eastern cultivars, all of which were less susceptible than turnip to spiroplasma infection. This study is part of a pest management program developed to explore biological and cultural alternatives to the routine application of chemical pesticides in horseradish production.

Identifying gypsy moth microsporidia

J. Maddox, M. Jeffords
Several species of microsporidia, biological control agents of the gypsy moth, were collected in Eurasia, the native home of the gypsy moth. These have now been introduced into experimental gypsy moth populations. The microsporidia recovered from these populations must be positively identified as the same species that were introduced. Ribosomal RNA sequences have therefore been determined for them. Because each sequence is unique, it can be used to identify a given microsporidium that was introduced into a field population.

Control of insects on woody plants

P. Nixon, R. Randell
American arborvitae were sprayed with several insecticides during the summer of 1988 to test their efficacy against bagworms. Their success increases the options of professionals as well as homeowners in maintaining aesthetically appealing plants in the landscape. A bacterial insecticide, a form of biological control, was sprayed on willow trees in the spring of 1989 to test its efficacy against willow leaf beetle larvae. Its success will prove useful to environmentally conscious arborists and will help to establish plantings near water bodies to reduce soil erosion.

Insects associated with horseradish

C. Eastman, H. Oloumi-Sadeghi
A study conducted in 1988–1989 in southwestern Illinois determined the incidence of insects associated with commercial horseradish production, especially leaf-feeding insects and their natural enemies. Sweep-net sampling, leaf collection, examination of whole plants, and sex-attractant traps were used to collect these insects. Parasites were reared from the diamondback moth, the imported cabbageworm, the cabbage looper, a leaf mining fly, and two predator species. Outbreaks of the false chinch bug and the diamondback moth required control measures during 1988, but preventive treatment for leafhoppers reduced the chance of a brittle root disease epidemic.

Insect control for horseradish

C. Eastman, H. Oloumi-Sadeghi, D. Dazey
Many horseradish growers apply insecticides several times a season to control disease vectors or to kill insects they believe may reduce yields. However, there is no quantitative evidence to suggest a relationship between these measures and yield. A field trial begun in 1989 in Madison County evaluated the effect of various levels of control on insect populations and horseradish yield. Treatments varied from applications at 2-week intervals from late May to mid-August to applications only upon recommendation of research personnel to no treatment. Insect populations are being monitored, and determinations of yield will be made in November.

Diamondback moth rearing

H. Oloumi-Sadeghi
Because the diamondback moth has developed resistance to many commonly used insecticides, it has achieved major status as a pest of cruciferous crops. Rearing this moth successfully in the laboratory is prerequisite to determining many of its bio-ecological characteristics. Studies of a diamondback moth colony (originally collected from horseradish fields) to determine its life cycle under laboratory conditions were completed, and sex ratio, female fertility and fecundity, developmental rates for various life stages, and reproductive biology of this species were determined. This information will be used to develop life tables for diamondback moth on cruciferous crops.

Insects associated with canola

C. Eastman, H. Oloumi-Sadeghi
In a study of potential insect pests on fall-planted canola, a field of this oilseed crop in Madison County was monitored every 1–2 weeks from March through June, 1989. Damage to the growing tips of canola was attributed to clover cutworm. Pods on plants in border areas were damaged by true armyworms emigrating from a nearby wheat field late in the season. Such pests as the diamondback moth, imported cabbageworm, and two species of aphids were occasionally observed in low numbers. Studies are planned to determine the incidence of pest and beneficial insects in this new crop in various production areas within the State.

Population dynamics of diamondback moth

H. Oloumi-Sadeghi, C. Eastman
The population dynamics of the diamondback moth in horseradish were determined in a 1988–1989 study at several field sites in southwestern Illinois. This moth appears to have six or seven generations each year, with the first generation developing on wild crucifers. Spring and late summer populations on horseradish were higher than those in mid-summer, and such factors as plant variety, presence of natural enemies, temperature, and rainfall influenced population size. Insecticides applied to control other insects may also affect the diamondback moth. Information on population dynamics is essential for effective pest management and in studying interactions between pesticides and the environment.



Diamondback moth preferences

H. Oloumi-Sadeghi, C. Eastman
Field studies were conducted in southwestern Illinois in 1988–1989 to confirm observations that diamondback moth populations differed among varieties of horseradish. Laboratory and greenhouse studies determined whether ovipositional preference and/or differences in rate of larval development occurred. Results indicate that females prefer Commons to either Swiss or Eastern for oviposition. Rates of larval development proved similar on all three varieties. This information can be used by horseradish growers in areas where damage by diamondback moths is of economic importance.

Microbial insecticides on cabbage

C. Eastman, H. Oloumi-Sadeghi, K. Kinney, D. Dazey
Microbial insecticides derived from *Bacillus thuringiensis* are being compared with a chemical pesticide for control of diamondback moth, imported cabbageworm, and cabbage looper on cabbage. Early results of a field trial in Champaign indicate that all insecticides reduced damage compared to damage in untreated plots. Differences were found among formulations and with regard to the efficacy of insecticide residues that remained on foliage after treatment. Bioassays indicated that diamondback populations in southwestern Illinois may be developing resistance to the synthetic pyrethroid insecticide most often used by horseradish growers.

Detoxification of pesticide waste

A. Felsot, E. Dzantor
Pesticide waste is created when farmers and homeowners rinse spray tanks and empty containers or spill concentrated pesticide products. That waste creates an environmental hazard in soil because it is highly concentrated and does not readily biodegrade. A search is being made for microorganisms that can readily degrade pesticide waste. Success in detoxifying comparatively high concentrations of herbicides has been achieved by adding ground corn and soybean residue to soil. The addition of extra nutrients to soil to help microorganisms break down waste is a procedure that can be easily adopted by homeowners and farmers alike.

Pesticide runoff in Court Creek watershed

A. Felsot, D. Roseboom

Understanding the sources and timing of pesticides moving into surface waters is important in developing watershed-based management practices to control runoff. Pesticide monitoring at Court Creek watershed has shown that cropland contributes the largest burden of pesticides to streams. The greatest amount is transported in May and June, coincident with spring rains and the application of farm chemicals. The most frequently detected pesticides are herbicides, not insecticides. Less reliance on herbicides and more reliance on integrated pest management will reduce the contamination of surface water.

Pesticide residues and fruit

A. Felsot

Consumers are worried about the health-related effects of pesticide residues in fresh produce. Although studies show that the frequency of detections is low and that the amounts found are very low, the washing of produce is recommended to remove surface residues. Two soaps were tested against water for the ability to remove fresh residues of the insecticide diazinon on apples. Neither soap removed more diazinon than did water alone. Scrubbing the apples with a brush was more effective than hand rubbing in removing pesticide residues.

Corn rootworm bibliography

E. Levine, P. Chan

Extensive research has been done on northern and western corn rootworms, the most injurious insect pests of corn in the Midwest, since previous bibliographies on these species were published in 1976. Consequently, this bibliography is now being updated. References from scientific journals, experiment station and extension publications, and masters and doctoral theses are being included along with indexing terms. This bibliography should prove valuable to corn research entomologists who are currently overwhelmed with the vast literature on this subject.

Chemical rotation to control corn rootworm

A. Felsot

Corn not rotated with beans on an annual basis risks damage from corn rootworms. Soil insecticides control corn rootworms in corn monocultures, but repeated use of the same chemical leads to its rapid breakdown (enhanced biodegradation) by resident soil microorganisms, thereby making the chemical ineffective. Research indicates that rotation of chemicals may help to maintain the effectiveness of some chemicals but not of others. The rotation of chemicals as a long-term strategy may help to prevent the development of insect resistance, but crop rotation remains the best practice for avoiding corn rootworm problems and eliminating the use of soil insecticides.

Pesticide contamination of groundwater

A. Felsot, T. Bicki

Occasionally very low concentrations of pesticides contaminate groundwater. Whether that contamination is from point sources such as spills or from nonpoint sources associated with agricultural practices is uncertain. The effects of tillage practices in combination with irrigation on the leaching of pesticides as nonpoint sources of groundwater contamination were investigated. Thus far in the study, tillage system and irrigation have had minimal effect on pesticide leaching. Research showed, however, that peak concentrations of pesticides occur in groundwater shortly after application, especially if heavy rains occur.

Genetic basis for extended diapause

E. Levine, H. Oloumi-Sadeghi

A trait called extended diapause allows some northern corn rootworm eggs to spend two or more winters in suspended development before hatching. This trait permits emerging larvae to damage corn even after a rotation crop such as soybean has been planted. Researchers have suggested that this trait may be expressed under certain environmental conditions and not under others. Studies are underway to determine if there is a genetic component for the trait as well. To that end, the hatch patterns of eggs from individual females collected in the field and those of specific matings of males and females in the lab are being studied.

Controlling pesticide runoff

A. Felsot, J. Mitchell

Past research has shown that the combination of contouring with no-till or strip-till field preparation can significantly reduce pesticide runoff. Recent research indicates that placing the chemicals deeper in the soil, such as with in-furrow applications, further reduces pesticide runoff.

Alfalfa weevil control

H. Oloumi-Sadeghi, K. Kinney, D. Dazey

The effectiveness of Lorsban, PennCap, and an insect growth regulator in controlling alfalfa weevil was evaluated in a 2-year-old stand of alfalfa. Sweep-net samples were taken on five dates post-treatment. Crop morphological stage of development, stem height, and forage yield and quality were measured. Lorsban and PennCap significantly reduced populations of weevil larvae on all sampling dates. The growth regulator affected neither larvae nor adults. The effect on parasites and predators varied according to the pesticide used. Plants in Lorsban- and PennCap-treated plots matured faster and grew taller than those in untreated plots, but no significant differences were observed in forage yield and quality.

Novel control of corn rootworms

E. Levine, H. Oloumi-Sadeghi, R. Metcalf

New strategies for corn rootworm control are needed to reduce damage to plants, decrease production costs, and reduce pesticide loads in the environment. The effectiveness of a corn rootworm beetle attractant derived from plants in combination with a feeding arrestant and small quantities of a toxicant as a bait is being investigated. Data on number of adults emerging per unit area, number of adults per plant, dead beetle counts per unit area, number of eggs laid per unit of soil, and root damage for baited and unbaited fields are being collected to determine if this bait significantly reduces beetle populations, egg laying, and root damage.

Rootworm egg-laying in soybeans

E. Levine, H. Oloumi-Sadeghi

Severe larval damage from western corn rootworm to corn grown for seed in fields following soybeans grown for seed was reported in fields near Piper City in 1987 and in a larger area in 1988. All fields were free of volunteer corn or heavy weed infestation the previous year, conditions that could lead to the unlikely occurrence of rootworm oviposition in soybeans. To test the hypothesis that adult rootworms may be laying eggs in soybeans that remain green after neighboring corn begins to turn brown, researchers planted soybeans at four intervals this spring and summer. This fall, egg samples will reveal if significantly more eggs were laid in soybeans planted later than in earlier plantings.

Resistant varieties of soybeans

M. Kogan, C. Helm, T. Chu, R. Bernard

A newly developed test with scores that range from highly resistant to susceptible permits the rapid classification of progenies in the breeding of soybean for resistance against foliage-feeding insects. Several thousand lines have already been screened and some two dozen are under closer investigation, looking toward the release of either a resistant variety of soybean or a series of germ plasm lines that might be of use to other soybean breeders. Some of the most resistant lines have also shown excellent seed quality, and this combination of traits would prove of great value to Illinois farmers.

Weed competition and soybean yield

C. Helm, M. Kogan, T. Chu

Farmers usually contend with various stress factors simultaneously affecting a crop, but few studies assess the combined effects of such factors. In this study, researchers looked at the competitive interactions between weeds and soybeans affected by foliage-feeding insects. Plots containing two densities of velvet leaf, a common weed in soybean fields, and three levels of defoliation at two different stages of plant growth were established. A decline in yield occurred as weed density and defoliation levels increased. Although the combined effects were greater than the individual effects of either single factor, they were smaller than the sum of the single effects.

Monitoring western corn rootworm

H. Oloumi-Sadeghi, E. Levine, R. Metcalf

The feasibility of using traps baited with plant volatiles to monitor western corn rootworm was studied in central Illinois cornfields. Baited and unbaited traps were placed on the south side of each field. Trapped beetles were counted, population abundance determined, and plant phenology recorded. Numbers of rootworm counted on corn plants significantly correlated with numbers caught, especially in unbaited traps. Baited traps proved most useful when beetle populations were near or below the economic threshold. Corn phenology influenced the correlation between field population and trap catch, and this relationship was stronger later in the season when plants were not silking.

Soybean resistance under field conditions

C. Helm, M. Kogan, D. Fischer

Plant resistance is a highly desirable method of insect pest control. As resistant soybean varieties are developed, their impact on such other control factors as parasites and predators of insect pests must be considered. Quarter-acre plots of the normally susceptible 'Williams 82' soybean and of a resistant line MBB 80-133 were established. Samples are being taken weekly to indicate the colonization patterns of these plots by pests and their natural enemies during the growing season. These data will help to determine whether or not the resistant line reduces the number of natural enemies.

Information on soybean research

J. Kogan, J. Bouseman, M. Kogan

Since 1969 the Soybean Entomology Program at the Survey has maintained two computerized data bases. SIRIC (Soybean Insect Research Information Center) is a bibliographic data base. ISAC (International Soybean Arthropod Collection) is a depository of insect specimens collected in soybean fields throughout the world. Together, SIRIC and ISAC represent a source of entomological information that is unmatched for any other major crop. In 1988 SIRIC published the *World Bibliography of Soybean Entomology*, a two-volume work that contains over 5,000 references and extensive indexes.

Reproduction in western corn rootworm

H. Oloumi-Sadeghi, E. Levine

To understand the reproductive biology of the western corn rootworm more completely, researchers determined the reproductive status of females reared in the laboratory and females collected in the field. Females of various age classes were examined under a binocular microscope and categorized by five stages, preovipositional through postovipositional. Additional studies are underway to quantify stages 4 and 5—the beginning of oviposition and post oviposition. This information should prove helpful in timing adult suppression techniques.



The deer tick in Illinois

J. Bouseman, U. Kitron, K. Todd, C. Kirkpatrick

During the last year the Survey, in collaboration with the Department of Veterinary Pathobiology of the College of Veterinary Medicine at the University of Illinois, monitored the establishment and spread of the deer tick, *Ixodes dammini*, in Illinois. To date, the tick has been detected in a dozen counties in Illinois (Carroll, Jo Daviess, Ogle, Lee, McHenry, Rock Island, Mercer, Knox, Putnam, Kankakee, Piatt, and Edgar). Large populations have been located in Ogle and Rock Island counties.

Soybean: mechanisms of resistance

D. Fischer, M. Kogan, H. Lin, N. Iannone
Soybean plants under stress activate biochemical processes that enhance the likelihood of overcoming the affects of stress. The chemical processes involved in the triggering of resistance by feeding insects are under investigation. Compounds generically referred to as phytoalexins are known to appear suddenly or to increase in concentration in plants infected by certain fungal pathogens. These same phytoalexins deter feeding by insects. An understanding of these resistance mechanisms may permit the use of genetic engineering in the production of insect-resistant soybean varieties.

How high do aphids fly?

M. Irwin, G. Kampmeier
Between 1983 and 1985, aphids were collected from as high as 1,200 meters above the ground. A follow-up of this study is investigating how such meteorological factors as temperature and wind speed govern the vertical zonation or layering of aphids in migratory flight. Tethered radiosondes beam back weather information while automated insect collectors mounted on helicopters trap aphids at selected heights under various weather conditions. Trajectories of aphid migrations based on this new data will lead to improved timing in control strategies.

Pesticides and the environment

L. Wei
The extensive use some twenty years ago of DDT in water treatments or in aerial spraying led to toxic residues in the mud of lakes and ponds. A principal route of DDT metabolism is dehydrochlorination to DDE, which has been found in fish for many years. Survey scientists recently used mass spectrometry to identify DDE in Canada geese. Because these geese regularly ingest large amounts of fish, they have come to contain nonbiodegradable DDE in their bodies. These findings add another chapter to the already sad story of human shortsightedness regarding toxic chemicals and the environment.

Callus tissue and soybean resistance

A. Schroeder, M. Kogan, D. Fischer
Small portions of soybean plants can be removed and the cells made to proliferate on an artificial medium. The tissue that develops is amorphous but similar to the tissue of origin. With manipulations, the callus may regenerate into an entire plant. In this study, callus was tested as a food for soybean looper larvae, which fed and developed on it as well as they did on soybean foliage. Surprisingly, tissue from soybean lines whose foliage is normally rejected by the larvae was accepted by them. Tissue treated with ultraviolet light, however, responded like that of whole plants and developed phytoalexins that deterred looper feeding.

Aphid colonization and aphid landings

M. Irwin, G. Kampmeier
Researchers have disagreed for years about the role of colonizing winged aphids in the spread of nonpersistently transmitted viruses in the same field. The landing rates of corn leaf aphids that had colonized sorghum did not increase in plots where sorghum and soybean were interplanted. Further, epidemics of soybean mosaic virus, which is transmitted by the corn leaf aphid, did not proceed faster in plots where aphids went unchecked than in plots where they were controlled with aphidicides. Apparently aphids that mature in a crop fly some distance before alighting, thereby lending credence to the notion that colonizing aphids contribute to the spread of virus only through nonflight movement or crawling.

Soybean phytoalexins

L. Wei
A technique has been developed to separate phytoalexins from other chemical compounds in order to identify the accumulation of phytoalexins in soybean plants under herbivorous stress. To date, the presence of one phytoalexin, glyceollin, has been confirmed by mass spectrometry. A better understanding of chemical defenses in such crops as soybeans is a necessary preliminary to the genetic engineering of insect-resistant varieties.

Studies of forest insects

J. Appleby
Insects in the genus *Heterocampa* are important defoliators of hardwood trees throughout the Midwest. Foresters must be able to recognize the early larval stages of these insects because delays in initiating control measures can result in extensive defoliation of trees. During this study, photographs of each developmental stage of *H. subrotata* and *H. guttivitta* were taken and descriptions of each stage recorded. This information will be valuable to foresters engaged in the suppression of insects.

Pesticide formulations

L. Wei
Terbufos formulated as Counter 15G is a soil insecticide used to control western and northern corn rootworm larvae. It is extremely toxic to humans and other warm-blooded animals. Although data on its persistence in soil has been reported, no studies on impurities in terbufos formulations have been published. In this study, analyses of Counter 15G were carried out via gas chromatography and mass spectrometry. All major impurities were identified, an essential first step in determining the persistence of these impurities and their environmental impact.

IR-4 National Pesticide Registration

L. Wei
The squash bug is a serious problem in the production of pumpkins and its control will allow Illinois growers to produce more and better pumpkins for processing. The objective of this project is to establish a tolerance for bifenthrin on pumpkin and to analyze quantitative residues. These data will be part of a national registration for the use of bifenthrin to control the squash bug.



FAUNISTIC SURVEYS AND INSECT IDENTIFICATION

Lawrence M. Page, Head

The mission of the Section of Faunistic Surveys and Insect Identification is to acquire and apply information about the diversity of life in order to protect, manage, and develop the biotic resources of Illinois in accordance with long-term environmental goals.

Public Service

The growing awareness that environmental changes induced by human activities threaten much of the world's biota with extinction has resulted in private and public efforts to protect species and the habitats critical to their survival. As a result, the need for sound biological data on threatened species and natural areas has never been greater.

Since its inception in 1858, the Illinois Natural History Survey has been accumulating the kind of information that is now vital for the protection of species and habitats. Among the responsibilities given the Survey through its enabling legislation were to conduct a natural history survey of the State, to furnish information fundamental to the conservation and development of natural resources, and to advise the various departments of the State regarding natural resources. Because the Survey conducts both basic and applied research, it is in a unique position to provide information and recommendations regarding environmental protection.

Statewide inventories have been completed in Illinois on about twenty taxonomic groups of animals, primarily various groups of insects but including other invertebrates and all classes of vertebrates. Among the early reports now considered classic were *The Ornithology of Illinois* by Dr. Robert Ridgway (1889), *The Fishes of Illinois* by Dr. Stephen A. Forbes and Dr. Robert E. Richardson (1908), and *The Caddis Flies, or Trichoptera, of Illinois* by Dr. Herbert H. Ross (1944).

Over the more than 130 years of the Survey's existence, inventories on certain groups have been repeated, thereby documenting historical changes in distributions and abundances. Information on past and present distributions permit comparisons between changes in the biota and changes in the landscape. Not only

do we know for many groups what species are currently present in Illinois and where they occur, but often we also know their status relative to earlier distributions and abundances. When a second *Fishes of Illinois* was published in 1979, its author, Dr. P.W. Smith, was able to make comparisons between distributions of fishes then and distributions in Illinois at the turn of the century. Such comparisons illustrate reductions in ranges of certain species (including the disappearance of some) and expansions of others (often ones that are considered pests).

The accumulation of information on the geographic and ecological distributions of animals in Illinois now exceeds that of any other state. When changes occur, these biotic surveys enable us to identify related environmental factors and to suggest protective or preventive measures.

The expertise of Survey scientists and the distributional and ecological data they gather are also used by other agencies to develop up-to-date lists of endangered species, harmful species, and potentially manageable species. Life-history studies and other ecological data enable state and federal planners to recognize significant natural areas and to formulate management plans for their protection.

The collections of preserved organisms based on statewide collecting efforts over the past century and on the acquisition of comparable material from other sources are another extremely important depository of historical and current information that is used in a variety of policy and management decisions. The Survey's collections are among the largest and oldest in North America and are used extensively by scientists throughout the world. The insect collection, containing about 6,000,000 specimens, is especially valuable because of its large holdings in several taxonomic groups. The fish collection, with about 500,000 specimens, is important not only because of its size but because it includes a number of specimens collected prior to the now extensive modification of the Illinois landscape.

Data associated with many of the Survey's collections, including the fish, amphibian, reptile, mammal, crustacean, and mollusk collections, have been computerized and are readily accessible to a variety of users. Requests for information are routinely received from state and federal agencies and from private firms conducting environmental impact assessments. These data have, for example, been used in the development of the Illinois List of Endangered and Threatened Species, the Natural Areas Inventory, and the Illinois Fish and Wildlife Information System.

Attention has recently focused on the need to protect wetlands, and the Illinois Wetlands Inventory was completed during the past year. This data base, grounded in the National Wetlands Inventory, represents the combined efforts of the Survey, the Illinois Department of Conservation, and the U.S. Fish and Wildlife Service. Illinois is one of the few states with wetlands data in automated form. In addition to location, configuration, and size, each wetland is characterized as riverine, lacustrine, or palustrine and further described by such factors as substrate type, vegetation, and hydrological conditions. These data have been used in several siting projects, including the siting proposal for the superconducting supercollider and in research related to the habitats of endangered species.

The wide representation of species in the Survey's collections enable scientists in the Faunistics Section to detect foreign species that are accidentally introduced or migrate into Illinois. The historical data, in the form of specimens collected over many years, document the first appearance and the expansion of introduced species. Such information is essential in the development of control measures.

Members of the Faunistics Section are experts on particular groups of organisms and ideally qualified to provide an identification service for other scientists, extension entomologists, government agencies, and Illinois citizens. Between 20,000 and 40,000 specimens are identified by them each year.

Special Recognition

The many invitations to present seminars, develop workshops, participate in symposia, and serve as officers in scientific societies indicate the scientific stature and accomplish-

ments of the Section of Faunistics and Insect Identification. Examples of special significance follow.

The Illinois Geographic Information System is one of the most advanced and heavily used systems in the nation. Its manager, Dr. Warren U. Brigham, serves as a state and national advisor on the management of large data bases. During the past year, he spoke on the geographic information system as an invited speaker at the National Governors Conference in Washington, D.C., served as an invited panel member at the Urban and Regional Information System Association Conference in Los Angeles, and coordinated a computer graphics session at the National Computer Graphic Association Conference in Orlando.

Dr. David L. Swofford's PAUP (Phylogenetic Analysis Using Parsimony) program is widely recognized as one of the best computer programs available for the analysis of the evolutionary relationships among organisms. The program is used throughout the United States, Canada, Europe, and Australia. During the past year, Dr. Swofford completed a major revision (PAUP 3.0) of the program that contains significant enhancements to earlier versions and was recently reviewed in the highly influential British journal, *Nature*. Because of his recognition as a leader in the development of methods for the analysis of systematic data, Dr. Swofford participated in the Seventh International Meeting of the Willi Hennig Society in Stockholm and in a symposium entitled "Computer-assisted Techniques in Phylogeny" at a meeting of the Geological Society of America in Denver. In addition, Dr. Swofford went to Karlskoga, Sweden, as an invited observer at the Nobel Symposium on "The Hierarchy of Life."

Several members of the Section are recognized authorities on the habitat requirements of endangered and threatened species. A number of invited appearances related to the habitat requirements of protected species were made, including a presentation on the use of radiotelemetry in the study of the federally endangered Indiana bat by Ms. Elizabeth A. Cook, Mr. James E. Gardner, and Dr. Joyce E. Hofmann at the Third Biennial National Workshop on Microcomputer Applications in Fish and Wildlife Programs in Stateline, Nevada; a presentation by Dr. Lawrence M. Page on outstanding aquatic ecosystems within Illinois at the Illinois Nature Preserves

Commission's 25th Anniversary Symposium in Carbondale; and a presentation by Mr. Kevin S. Cummings and Ms. Christine A. Mayer on the decline of the freshwater mussels of the Wabash and Tippecanoe rivers at the Annual Meeting of the Indiana Chapter of the North Central Division of the American Fisheries Society in Fort Wayne, Indiana.

Grants from the National Science Foundation are highly competitive. A rigorous review process ensures that only accomplished scientists with proven productivity and excellent ideas for research receive grants. Recent grants supported Dr. Wallace E. LaBerge's research on bees, Dr. Lawrence M. Page's research on fishes, and Dr. David L. Swofford's phylogenetic analysis of systematic data. In addition, two National Science Foundation grants were received to underwrite the cost of installing compactors, which were provided by the Illinois Capitol Development Board. These compactors store the Survey's Insect Collection efficiently and safely. During the past year, Drs. David L. Swofford and Warren U. Brigham served on National Science Foundation advisory panels that help determine the direction of research funding.

Offices and positions in scientific societies are generally elective and filled by scientists with the highest professional stature. Currently, Dr. Lawrence M. Page is a member of the Board of Governors and the editorial board of the American Society of Ichthyologists and Herpetologists. Dr. David L. Swofford is special associate editor for the Society for the Study of Evolution, a member of the editorial board for the Smithsonian Series in Comparative Evolutionary Biology, and a councilor for the Society of Systematic Zoology. Dr. Donald W. Webb chairs the Literature Review Committee of the North American Benthological Society.

Research Reports

The research that is summarized on the following pages documents the Section's interest in maintaining threatened and endangered species and their sometimes fragile habitats. It makes clear the importance to present-day researchers of the systematic studies done by their predecessors and by extension underscores the significance of the research currently underway to the systematists of the future.

Spottail darters

L. Page, P. Ceas, D. Swofford

Approximately one-fifth of all North American freshwater fishes are darters, small fishes that are often present in large populations and have a major impact on the ecological characteristics of streams and lakes.

Among the most interesting are the spottail darters that occupy headwater streams in southern Illinois and the southeastern United States. Isolation in headwater streams resulted in differentiation among populations that has only recently been studied. The complex, originally thought to consist of highly variable populations of only one species, is now known to contain 10 species. Several of these occupy small stream systems and are vulnerable to extirpation.

Life history of the bullhead minnow

P. Ceas, L. Page, K. Cummings

The bullhead minnow, *Pimephales vigilax*, is one of the most common fishes in medium-sized rivers of the Midwest. In spite of its abundance and obvious impact on the ecological character of Illinois streams, little ecological data exist on this species. Three years of data on the Embarras River population have been gathered and are being analyzed. Among the interesting characteristics are an extremely complicated breeding behavior involving paternal care of the eggs and a diet consisting in part of terrestrial plant seeds.

Life history evolution in percoid fishes

H. Bart, Jr., L. Page

Life histories of organisms evolve to optimize reproductive success and vary in response to environmental impacts on the survival and fertility of different age classes. Body size and phylogenetic history limit the choice of survival and reproductive alternatives. Covariation in life history traits was examined in 66 species of percoid fishes. Most traits, including size at maturity, longevity, and number of eggs produced, correlated with female size; larger species live longer, mature later, and produce more eggs. Egg size and reproductive behavior did not correlate with size or with phylogenetic relationships and thus appear to vary with ecological factors (e.g., size of stream occupied).

Scanning electron microscopy

M. Retzer, L. Page, K. Cummings

The recent acquisition of a scanning electron microscope by the Geological and Natural History surveys provides an excellent opportunity to study the microstructure of animals. The examination of the reproductive structures of Illinois isopods (pill bugs) has led to the discovery of a new species, as yet unnamed, known only from Illinois. Study of the microstructure of the larvae of the fat pocketbook, a federally endangered mussel, will permit these larvae to be separated from those of related species and allow the identification of the larval host. This information is important for researchers monitoring the status of Illinois populations of this mussel.

Mandibles of Notodontidae larvae

G. Godfrey, D. Dockter

Understanding the variability of larval mandibles is important in the identification of notodontid moths, which feed on broad-leaved, woody plants. *Heterocampa guttivitta* is oligophagous (e.g., oaks and maples), and *H. subrotata* is monophagous on hackberry. Research is underway to determine if leaf texture influenced the mandibular morphology of these two species and if so, to what degree.

Mouthparts of notodontid caterpillars

G. Godfrey, J. Miller, D. Carter

Relationships among the Notodontidae (Noctuoidea), a worldwide group of 3,000 moths, are poorly understood. Because larval mouthparts have been shown to contain useful phylogenetic characters for other noctuids, 90 genera of notodontid caterpillars are being studied from the standpoint of functional morphology and phylogenetic implications. Results from this study will help to clarify the phylogenetic relationships of the Notodontidae to other noctuids.

Stick catfishes

M. Retzer

The loss of Neotropical biodiversity is of concern to scientists everywhere. One of the major tasks is to inventory the biota and in the process identify centers of diversity and endemism so that these areas may be protected. As part of this effort, a study of stick catfishes, a group of armored catfishes distributed from Venezuela to Argentina and thought to contain about 40 species, has been initiated. The completed study will be submitted to the University of Illinois as a doctoral dissertation and is expected to contribute significantly to our understanding of the diversity of the fish fauna of South America.



Little Wabash River mussels

K. Cummings, C. Mayer, L. Page.
Illinois historically supported a diverse freshwater mussel fauna, but many species have become rare and some have been placed on endangered species lists. A survey of the mussel fauna of the Little Wabash River in southeastern Illinois was completed in the summer of 1988. Thirty-two of the 40 species known to have lived in that drainage were found, but only 26 of those were collected alive. Compared to a study in the 1950s, reductions were found in the number of individuals and in the number of species. These data are consistent with other recent mussel surveys and reflect the need for increased protection for aquatic habitats in Illinois.

Wabash River mussels

K. Cummings, C. Mayer, L. Page
The second phase of a 3-year survey of the freshwater mussels of the Wabash River drainage in Illinois and Indiana was conducted in 1988. This cooperative study between the Survey, the Indiana Department of Natural Resources, and the U.S. Fish and Wildlife Service documented changes in the mussel fauna with a particular emphasis on endangered species. The Wabash has undergone drastic changes over the past 100 years, and only 35 of the approximately 75 species of mussels known from the drainage were found alive in 1988. Identifying areas where significant and diverse mussel populations occur will help ecologists protect the remaining species.

Freshwater mussels of Illinois

K. Cummings
A new *Naiades or Freshwater Mussels of Illinois (Mollusca: Unionidae)* is targeted for publication in 1993. This monograph will reflect changes in nomenclature, provide detailed data on distribution, and update the biological literature since the 1967 publication of P.W. Parmalee's *Fresh-water Mussels of Illinois*. A computer data base containing information on the distribution of Illinois mussels is near completion and includes information from the Survey, the University of Illinois Museum of Natural History, the Illinois State Museum, the Field Museum of Natural History, the Chicago Academy of Sciences, and six out-of-state museums.

Identification of creek chubs

C. Johnston, J. Ramsey
Semotilus thoreauianus, the dixie chub, was originally described in 1877 and synonymized with *Semotilus atromaculatus*, the creek chub, only a few years later. A recent study supports the specific status of the dixie chub, which differs from the creek chub in coloration, tuberculation, and scale size. Dixie chubs are found in Gulf Coast drainages from Mobile Bay east to the Ochlockonee River. Results of this study will help us to interpret variation within the creek chub, one of the most common species in Illinois.

Spawning in eastern sand darters

C. Johnston
Descriptions for 73 species of darters in the genera *Etheostoma* and *Percina* are available but none has been published for any species of the genus *Ammocrypta*. A study of the spawning behavior of the eastern sand darter, *Ammocrypta pellucida*, was conducted to improve our understanding of the evolution of breeding behaviors in darters and to provide valuable life history information for this threatened species. Members of this species bury their eggs and have morphologically unusual larvae.

Nest association

C. Johnston
Nest association, the habit of spawning in the nest of another species, is widespread among North American minnows. Nest associates use the nests of sunfishes or, more commonly, the nests of nest-building minnows. Experiments to determine the costs and benefits of this strategy to host and associates are currently underway. Five species for which spawning behavior had been unknown were discovered during the past year to be associates of nest-building minnows.

Evolution of breeding behaviors in minnows

C. Johnston, L. Page
Reproductive behaviors have been described for 89 species (about 40% of the total) of native North American minnows. Eight types of breeding behaviors (broadcasting, crevice-spawning, saucer-building, pit-building, pit-ridge building, mound-building, egg-clumping, and egg-clustering) were compared with published phylogenetic hypotheses. Some behaviors (e.g., clustering) appear to have evolved within the North American Cyprinidae only once; others (e.g., mound-building) have evolved more than once. Where sufficient data exist, cladistic analysis of the behaviors helps to explain their evolutionary history.

Pugnose minnows

L. Page, C. Johnston
The pugnose minnow, originally described as *Opsopoeodus emiliae*, was transferred to *Notropis* in the 1970s. Its taxonomy has been confused since then. A study of the breeding behavior of the pugnose minnow was undertaken in order to understand its phylogenetic relationship to other species. Pugnose minnows were found to have a derived breeding behavior, which has been termed egg clustering, that was previously known to occur among North American minnows only in *Pinephales* and *Codoma*. This finding supports the hypothesis that pugnose minnows are closely related to *Pinephales* and *Codoma* and should retain the generic name *Opsopoeodus*.

Alternative reproduction in minnows

J. Berlocher, L. Page, E. Macleod
Alternative reproductive tactics may play an important but unrecognized role in the life histories of many species. Breeding male bluntnose minnows (*Pinephales notatus*), for example, typically develop cephalic tubercles and compete for spawning territories, which may be scarce and are often controlled by the largest males. As a result, many smaller males probably never hold territories of their own. In other territorial fishes, however, small males circumvent such competition by spawning in the territories of larger, dominant males. This tactic is difficult to observe, but indirect information can be obtained by microscopic examination of the testes of smaller, nontuberculate males.

Relocating and monitoring mussels

J. Berlocher, M. Wetzel

Federal and state conservation agencies recognize the importance of protecting freshwater mussel communities. Accordingly, the U.S. Fish and Wildlife Service recommended that mussels be relocated from the vicinity of a soon to be demolished bridge over the Kankakee River. During 1987, over 3,000 mussels were removed from the vicinity of the bridge and relocated to two sites upstream. Over the next 2 years, Survey biologists monitored the survival, growth, and movements of these populations. Information on age structure and other features of mussel ecology is also being compiled.

Snipe flies

D. Webb

As part of an ongoing systematic study of the lower brachycerous Diptera, the genus *Rhagio* (New World snipe flies) was revised. These small-to-moderate-sized flies occur in shady humid habitats. Twenty-six species or subspecies previously recognized were considered valid, and six new species were discovered. Three of the new species occur in the Neotropical region, an area from which *Rhagio* was not previously reported. The distributional pattern of this genus closely correlates with climatic and vegetation zones.

PAUP: Version 3.0

D. Swofford

Earlier versions of PAUP (Phylogenetic Analysis Using Parsimony) have been well received by the systematics community, and the program has become a standard tool for reconstructing evolutionary relationships among species. The program is widely used throughout the United States, Canada, Europe, and Australia. Version 3.0 is the first release to run on Apple Macintosh computers and is currently being adapted for the IBM PC and for several minicomputers and mainframe systems. The new version deals with a broader variety of evolutionary models and has a completely redesigned user interface.

Aquatic oligochaetes (Annelida) of Illinois

M. Wetzel

The inland waters of Illinois, including springs, swamps, marshes, ponds, lakes, reservoirs, and streams, offer a variety of habitats for aquatic macroinvertebrates. Although most studies of aquatic macroinvertebrates identify specimens by family, genus, and often species, they rarely report the presence of oligochaetes at other than the ordinal level. Oligochaetes, however, are an important group in aquatic ecosystems because of their nutritional value to higher trophic levels. Because knowledge of this group is scant, a study of the aquatic oligochaetes of the State has been initiated. Of the 150 species known to occur in North America north of Mexico, 65 occur in Illinois.

Stilto flies

D. Webb, M. Irwin

A study of New World stilto flies began with the revision of the following three genera: *Ataenogera*, *Phycus*, and *Pallicephala*. Members of *Ataenogera* and *Phycus* are moderate-sized flies that occur in sandy dry environments; the immature stages are mobile predators in sandy soil. Two new species were discovered and described for *Phycus*, a genus that had not previously been reported from the New World. Prior to this revision, the genus *Pallicephala* was thought to be a complex of two species and four subspecies. The data generated clearly indicate that the genus contains six species, including one that is new to science.

Reference collection of aphids

D. Voegtlin

More than 1,500 species of aphids are found in North America. Only a small percentage of these can be considered pests of cultivated plants. Discriminating between the pest species and the many nonpest look-a-likes can be difficult, and a reference collection of identified material is of great importance. This past year over 150 aphid species were added to the Survey's insect collection through exchanges with entomologists at Utah State University. The total number of aphid species in the collection is now around 900; about 750 of these are from North America.

Data base of Illinois Lepidoptera

G. Godfrey, E. Cashatt

The data base of Illinois Lepidoptera collates historic information on the moths and butterflies of Illinois. These data help to document the distributions of the State's approximately 2,000 species of moths and butterflies. Since January 1989, 8,770 collection records representing 144 species have been transcribed from specimen labels and 7,294 have been entered into computer files. Records were obtained during visits to 13 institutional and private collections within the State and cover 470 localities within Illinois from 1876–1988. This information will help to identify species that should be placed on the list of endangered species in Illinois.





Variability in the potato aphid

D. Voegtlin

No North American aphid lives on soybeans; however, one species, *Aulacorthum solani*, which is worldwide in distribution and known as the potato aphid in the United States, occurs on soybeans in Japan and China. Its absence on soybeans here has not been explained. In cooperation with a U.S. Department of Agriculture scientist in Maryland, cultures of this aphid were obtained from stocks in Japan, New Zealand, California and New Brunswick. Morphological studies revealed that the soybean-feeding population and the potato aphid are readily distinguished. Indeed, the differences were so great that the two forms are now considered separate species.

Native bees

W. LaBerge

Native bees include bumble bees, sweat bees, leaf-cutter bees, carpenter bees, and solitary bees. Among the most interesting are the solitary (each female constructs a nest and provides for her own progeny) ground-nesting bees. Their largest genus in North America, *Andrena*, includes about 500 species. A systematic revision of this genus is approaching completion, and the publication will include detailed descriptions of each species, a key to their identification, locality and floral records, maps showing the distribution of each species, and illustrations. Other genera of solitary bees undergoing revision include *Anthidium* and *Tetraloniella*.

Bat habitats in the Shawnee National Forest

J. Gardner

The multiuse policies of the U.S. Department of Agriculture Forest Service (e.g., recreation, timber sales, clear cuts) sometimes jeopardize threatened species and their habitats. Four species of bats endangered in Illinois, two of which are also federally endangered, are found within the Shawnee National Forest. Distributional data on bats captured in southern Illinois are being combined with habitat features (forests, streams, topography) from the Illinois Geographic Information System. This highly detailed information will help the Forest Service develop the Shawnee National Forest Land and Resource Management Plan and its accompanying Environmental Impact Statement.

Radio tracking the Indiana bat

J. Gardner, J. Hofmann, J. Garner

Populations of the federally endangered Indiana bat are declining at an alarming rate. More than 95% of the remaining 185,000 are protected (by gates or fences) in seven major winter hibernacula in Missouri, Kentucky, and Indiana, but little has been done to identify and protect their summer habitat. Females migrate north of their winter caves and establish nursery colonies beneath the loose bark of trees. Some areas in Illinois offer excellent summer habitat for Indiana bats, and provide a rare opportunity for radio-tracking studies. Identifying and describing the foraging ranges and nursery trees of reproductively successful females is imperative to the continued existence of the Indiana bat.

Southeastern bat ecology

J. Gardner, J. Hofmann, J. Garner, R. Porter, K. Neelley

In March 1989, the southeastern bat (*Myotis austroriparius*) was declared an endangered species in Illinois. The small Illinois population is found only in the southern tip of the State and is probably disjunct from populations in more southern states. This bat hibernates in mines and caves, and little is known about its reproductive ecology. Reproductively active females have been captured over streams in southern Illinois, and a nursery colony was identified by radio tracking. Reliable information on the reproductive ecology of this bat will help the U.S. Fish and Wildlife Service make a decision concerning federal protection.



WILDLIFE RESEARCH

Glen C. Sanderson, Head

The mission of the Section of Wildlife Research is to undertake scientific inquiry concerning the life histories, dynamics of abundance and distribution, genetics, and ecology of the vertebrate, warm-blooded wildlife of Illinois; to acquire, organize, and use data pertaining to all aspects of these resources; and to provide information and to make recommendations concerning their status, protection, development, and use.

Public Service

In a broad sense, all activities of the Section of Wildlife Research relate to public service in one way or another. Some provide information and assistance directly to the public:

“How do I get skunks out from under my front porch and then keep them out?” and “When are the most mallard ducks found in Illinois?”

Others provide information directly to such state and federal agencies as the Illinois Department of Conservation and the U.S. Fish and Wildlife Service. For example, the Department of Conservation recently asked for recommendations regarding changes in hunting regulations for rabbits and the Fish and Wildlife Service requested information on the effects on wildlife of a proposed reflooding of Thompson Lake along the Illinois River. The Section also provides a wide variety of information on a regular basis (periodic waterfowl census data, for example) and in response to specific requests (“What is the status of Lyme disease in Illinois?”) from newspapers, magazines, and radio and television stations. The information on which the answers to these questions are based comes from research conducted by members of the Wildlife Section integrated with the data of other researchers.

Because an extension staff to provide information and implement recommendations regarding wildlife is not available in Illinois, this service must be provided by researchers, and often the number of requests for information seriously interrupts research. The fourteen senior biologists on the Section’s staff on average respond to two requests for information per working day—approximately 7,300 requests each year. An indication of the range and variety of this public service can be seen in the sampling given here.

Public interest in the aerial censuses of waterfowl and eagles throughout Illinois and the Midwest remains high. In addition to mailing the census information to various agencies and responding to numerous telephone inquiries from private citizens and public employees, the Section provided waterfowl census data during the hunting season for weekly columns in St. Louis, Peoria, Quincy, and LaSalle-Peru newspapers.

The wildlife research programs at the Forbes Biological Station have proved popular with the media and the citizens of Illinois. Feature articles highlighting these studies appeared in the *Peoria Journal Star*, *Pekin Daily Times*, *Mason County Democrat*, *Effingham Daily News*, and *Jacksonville Journal Courier*. The Director of the Forbes Biological Station, Dr. Stephen P. Havera, was interviewed for a feature article, “A Day in the Life of the Havana River Research Laboratory,” in the fall 1988 issue of *The Nature of Illinois*. Newspapers such as the *Des Moines Register* periodically ask for information about research findings made at the Station. In addition, Director Havera gave radio interviews with WBYS in Canton and WTAX in Springfield, served as a consultant for a river documentary to be aired on WILL-TV, Champaign, and acted as technical advisor for a series of six video tapes for the Society for the Illinois Scientific Surveys.

During the past year, staff of the Forbes Biological Station provided recommendations on waterfowl management strategies in conjunction with site visits to at least six public and eight private waterfowl clubs. Bird remains from bird-plane collisions were identified for the U.S. Air Force and the Illinois Department of Conservation. During the year, over 350 visitors came to the Biological Station to discuss research programs, to obtain information, or to assist with station business. Visitors represented a broad spectrum of interests, including the U.S. Army Corps of Engineers, U.S. Geological Survey, Illinois Department of Conservation, Capital Development Board, Environmental Protection Agency, Dickson Mounds Museum, Illinois State Museum, Air National Guard, Department of Energy and Natural

Resources, Private Industry Council's Hope Program, Society for the Illinois Scientific Surveys, faculty and students from five universities, media representatives, and interested citizens. This tally does not include the nearly 200 visitors who attended the dedication of the addition to the Forbes Biological Station. Station Director Havera served on the Planning Committee for the Illinois River Environmental Awareness Week and for the Jacques Cousteau Presentation, "Rediscovering the World," to be held in Peoria in November 1989.

Forest Wildlife Biologist Charles M. Nixon gave interviews regarding Illinois deer populations and their management to the *Champaign News Gazette*, *Peoria Journal Star*, *Kankakee Journal*, and *Alton Telegraph*. Dr. James Witham of the Urban Deer Project responded to more than twenty-five requests for information on urban deer from newspapers, magazines, television, and radio, primarily in the Chicago Metropolitan Area.

The Urban Deer Project developed a file of reprints on deer population management, damage abatement, Lyme Disease, and other deer-related subjects in response to questions commonly asked by the public. Copies of articles in this file were given to the Urban Project Manager of the Illinois Department of Conservation, who will maintain and expand the file and continue to provide this information to the public. The Urban Deer Project also provided technical advice on urban deer management to the Lake County Forest Preserve District, the Illinois Department of Conservation, and the Illinois Nature Preserves Commission during litigation involving deer management on the Rycerson Conservation Area in Lake County.

Special Recognition

Awards are by their nature rare; however, special recognition of members of the Section of Wildlife Research is not uncommon and can be measured in part by the number of times they are asked to serve as editors for books or symposium proceedings, as reviewers for scientific journals, as members of peer review committees for scientific proposals, as consultants or expert witnesses on state and federal court cases, as resource persons for public and private agencies in the development of public policies, and as consultants for television documentaries and newspaper and magazines stories.

Dr. Scott K. Robinson was voted Elective Member of the American Ornithological Society and chosen Outstanding Teacher by the students of his ornithology class at the University of Illinois at Urbana-Champaign. Dr. Glen C. Sanderson was promoted to Principal Scientist by the Illinois Natural History Survey and also received Honorary Life Membership in The Wildlife Society, the international organization of professional wildlifers. Dr. Ronald P. Larkin's U.S. Air Force project was recognized as the top study in Air Force research on collisions between bird and aircraft.

Seven members of the Section hold eight affiliate, joint, or lecturer appointments in three universities: two appointments in the Biology Department, Western Illinois University; one in the Biology Department, Bradley University; one in the Animal Science Department, one in the Forestry Department, and three in the Department of Ecology, Ethology, and Evolution, University of Illinois at Urbana-Champaign.

Virtually all senior scientific staff members serve as referees for manuscripts sent to them by editors of journals, proceedings, and books. During the past year, the staff reviewed more than fifty manuscripts for eleven journals, including *Ank*, *Behavioral Ecology and Sociobiology*, *Animal Behaviour*, *Transactions of the Illinois Academy of Sciences*, *Journal of Wildlife Management*, *Wildlife Society Bulletin*, *Journal of Mammalogy*, *The Wilson Bulletin*, and *Science*. The staff also refereed manuscripts from two symposia and provided peer review for one research proposal for the National Wildlife Federation and two for Earthwatch.

Dr. William R. Edwards served as technical editor for *Pheasants: Symptoms of Wildlife Problems on Agricultural Lands*, the proceedings of a symposium sponsored by the North Central Section of The Wildlife Society. Dr. Stephen P. Havera is serving as editor for the Proceedings of the 1988 North American Wood Duck Symposium; publication is expected in 1989.

Members of the Wildlife Section have also been invited to lecture at a number of universities and professional societies. Dr. Havera presented seminars at Bradley University and to waterfowl classes from the University of Missouri and Mississippi State

University. Dr. Robinson gave a seminar on Yellow-rumped Caciques at the University of Hawaii, the University of Colorado, and the University of Chicago. Dr. Sanderson presented the opening address at the 50th Anniversary Meeting of the Midwest Fish and Wildlife Conference in Columbus, Ohio, and was the keynote speaker at the Annual Meeting of the Texas Chapter of The Wildlife Society. Dr. Richard E. Warner gave the keynote address at the State Leadership Council of Pheasants Forever in Paxton and the keynote address at the Upland Game Bird Conference in Frederick, Maryland. He was also an invited speaker at the International Right-of-way Symposium in Peoria.

On 5 May 1989 the Forbes Biological Station commemorated the 95th anniversary of the establishment of the station, the 50th anniversary of the first permanent building, the dedication of the new addition, and the naming of the station after its founder, Dr. Stephen A. Forbes, first Chief of the Natural History Survey. Dignitaries from around the State and representatives from the news media attended the luncheon and ceremony during the morning. A proclamation declaring 5 May 1989 as Stephen A. Forbes Biological Station Day in the State of Illinois was presented from the Office of Governor James R. Thompson. Guest speakers were Karen Witter, Director, Illinois Department of Energy and Natural Resources; T. Miller, Illinois Department of Conservation; Arthur S. Hawkins, U.S. Fish and Wildlife Service (employed at the station from 1938 to 1946); Leonard Ferrington, President-elect, North American Benthological Society; and Harry K. Nelson, U.S. Fish and Wildlife Service. Organizations represented at the ceremony included the Department of Conservation, U.S. Fish and Wildlife Service, Department of Energy and Natural Resources, and Illinois Environmental Protection Agency. In September 1988 the United Private Industry Council awarded the Forbes Station special recognition for its participation in the Summer Youth Employment Program and for supervisory excellence.

Research Reports

Thirty research projects are summarized in the following pages. They document the concern of the Section for the wildlife of the State and make clear how practical applications grow directly from basic research. The wildlife management strategies recommended by the Section are truly research in action.

Rabbits have their ups and downs

W. Edwards

In November 1988 cottontails on the 4-H Area at Robert Allerton Park in Piatt County were inventoried for the 33rd consecutive year. This unique series of fall estimates is one of the longest continuous data sets on annual fluctuations in local abundance of cottontails in the Midwest. Approximately 70–80 cottontails were using the area, almost 300 below the high observed in 1976 and about 100 less than the long-term average. Numbers crashed in the late 1970s and apparently went to zero in the winter of 1981–1982. Recolonization occurred in the spring or summer of 1982 and has been followed by a slow recovery of rabbit numbers.

Prairie pastures for beef and wildlife

R. Westemeier

For the past 2 summers, weight gains for yearling steer on prairie grass pasture and on conventional grasses were compared on the McCormick Prairie-chicken Sanctuary in Jasper County. Gains doubled from 0.5 pound average daily gain in 1988 to 1.0 pound in 1989; however, no differences in gains were found between pasture types. Drought may have suppressed gains both summers because gains of 2 to 3 pounds per head were reported for steers grazing warm-season grasses in other states. Researchers will evaluate alternatives to existing management of sanctuary grasslands and the use of prairie grasses on private land for beef production, wildlife habitat, and soil erosion control.

The white-cheeked geese

H. Hanson

Preparation for a book based on 25 years of research on the white-cheeked geese is nearly completed. Three species and over 125 races make up this complex and provide an outstanding example of biodiversity. The manuscript includes 188 morphometric diagrams, 90 maps, some two dozen tables, and approximately 500 photographs. The latter include types or paratypes, living birds, and low-level aerial obliques of breeding ranges from Newfoundland to the Queen Charlotte Islands and Alaska. The taxonomic portion of the manuscript holds particular significance for future management and conservation efforts.

Cottontails and wildlife management theory

W. Edwards

A cottontail data base of 33 consecutive years along with other data provide a basis for a much needed revision of ecological and wildlife management theory. Old ideas of equilibrium, regulation of abundance, and balance of nature are rejected, and abundance is thought to be determined more by fluctuations in survival and dispersal and less by reproduction. The emerging perspective is one of nonequilibrium and variable abundance in a world "patchy" across space in which patches change over time. Persistence of a species is facilitated by sustained high levels of reproduction, dispersal, and genetic diversity.

Deer populations in Illinois

C. Nixon

Each year data related to the deer harvest in Illinois are computerized. Harvest totals, sex and age breakdowns, and hunter success are developed for each county and deer region and for the State as a whole and downloaded to disks for use by the Department of Conservation. Computer models of county deer populations are also developed each year to study population trends and projected hunting pressures. Allocations for hunting permits are discussed with the Department of Conservation, taking into account hunter demand, deer population, and landowner tolerance for deer. The goal is to accommodate hunter demands and at the same time manage deer to minimize conflicts with landowners.

Strategies for managing winter deer habitats

C. Nixon

In central and northern Illinois, deer congregate in winter in larger forests (>200 ha) and in refuges closed to firearm hunting to reduce the effects of harsh weather and to escape hunters. Most of these sites are located along streams, which provide forested corridors among landscapes dominated by agricultural fields and urban development. Management of these wintering sites requires protecting enough deer to provide dispersing and migrating numbers to restock surrounding smaller, scattered woodlots and at the same time controlling deer numbers within the wintering sites to prevent widespread damage to farm crops and natural vegetation.

Life history and ecology of farmland deer

C. Nixon, L. Hansen, P. Brewer, J. Chelstvig

In a 5-year study in east-central Illinois, marked deer (N = 287 of which a portion were radio marked) were used to determine demographic characteristics, seasonal movements, social interactions, habitat selection, and value of refugia in a landscape heavily affected by human activities. Important findings include extensive dispersal movements by both sexes and the survival value of scattered refugia in landscapes where forest cover is scarce and hunting pressure high. At present, deer numbers are increasing in Illinois because of high natality, very high fawn survival, and significantly higher survival of yearling and older females than males.



Parasites of blackbirds

S. Robinson, C. Kirkpatrick, U. Kitron

Growing evidence suggests that blood parasites (similar to malaria in humans) have a major impact on bird populations and on the reproductive success of males. A detailed study of Common Grackles in Urbana showed that most individuals were infested by parasites. Surprisingly, no evidence was found that these parasites affected the health of adult grackles. Even heavily parasitized individuals appeared to be normal in size, coloration, and breeding success. Apparently, most of the parasites of grackles are benign.

When will raccoon numbers decline?

G. Sanderson

Raccoon numbers in North America began a sharp increase in 1943, an increase that continued for 6–8 years and leveled with numbers 10 to 15 times higher than those in the 1930s and early 1940s. Contrary to expectations, numbers have remained high for 40 years. Although small annual variations are caused by the effects of weather on reproduction and vulnerability to hunters and trappers, Illinois data for the past 34 years show no trends in such characteristics as body weight, reproductive rate, and age and sex ratios. The raccoon continues to be the most valuable furbearer in the State, with 140,000 pelts worth \$882,000 to hunters and trappers.

Grassland birds and farmland edge habitats

R. Warner

Farmland edges comprise most of the semi-permanent grasslands in midwestern agricultural environments. To determine the productivity of grassland birds in these habitats, a nest study was conducted from 1976–1980. These linear habitats attracted relatively few grassland birds. Many of the passerines experiencing major declines in the Midwest tended to nest on farmland plots relatively remote from farmsteads, where corridor networks connected nest sites with other key habitats. These data suggest that some linear habitats are relatively productive for nesting birds.

Population dynamics of a tropical oriole

S. Robinson

Recent work has shown that predation plays a more important role in wildlife population dynamics than has often been supposed. A 10-year study of a population of colonial orioles in an Amazonian field site indicates that population sizes and nesting success are determined by the activities of just one species of predator, the Great Black-hawk. The population of birds nesting on an oxbow lake dropped by 90% after a new pair of hawks moved into the area. The British Broadcasting Corporation filmed these Orioles in 1988 and will return to continue filming them in 1989.

Terrestrial ecosystems and farm programs

R. Warner

Farm policies in Illinois after World War II fostered intensive row-crop farming and resulted in a loss of upland wildlife habitat. Multiple regression models and data sets indicate that the effects of those policies on the integrity of terrestrial ecosystems as measured by the quality of upland wildlife habitat can be quantified and predicted. The farm policy-making environment of the 1980s and early 1990s is unique because it includes a planning phase for the integration of natural resource objectives with broader goals in agriculture. Phase II of the program emphasizes alternative means of addressing farm commodity programs and soil and water quality goals.

Deer management in the Chicago area

J. Witham

The Survey's Urban Deer Study concludes in December 1989. Recommendations include a permanent Urban Deer Management Project under the Department of Conservation that will function as a wildlife extension service in the Chicago Metropolitan Area, guidelines for managing white-tailed deer on Illinois Nature Preserves, restrictions on the translocation of deer for the purpose of population reduction, minimal requirements for issuing permits for deer removal, and amendments to the Good Samaritan Food Donor Act to improve efficiency when donating wildlife carcasses for human consumption to charitable organizations.

Habitat fragmentation and Illinois birds

S. Robinson

A summer's work in the Shawnee National Forest suggests several trends. Cowbirds are found virtually everywhere, including deep in the forest interior. Their population densities vary among study sites, but the reason is unclear. Many of the primary study species are common and widespread (Wood Thrush, Kentucky Warbler, Worm-eating Warbler, Northern Parula, and Louisiana Waterthrush). Their high densities suggest that they are at or near the carrying capacity of the environment, and it is unlikely that their populations could be maintained through immigration. Several species (Cerulean and Hooded warblers, Ovenbird, Black-and-white Warbler, and Red-eyed Vireo) may be declining.

The Illinois pheasant range 1958–1988

R. Warner

The Rural Mail Carriers' Pheasant Census of 1988 has been compared with those conducted at 5-year intervals since 1958. In 1988 carriers recorded an average of 1.1 pheasants per 100 miles of driving, an increase of 120% over the 1983 average; nevertheless, the 1988 figure represents a decline of 88% from that recorded in 1963. Important findings are the continued expansion of the pheasant range in western and southwestern Illinois and the low number of pheasants per unit of grassland habitat in the prime range (east-central counties) compared to that of the 1950s, 1960s, and early 1970s.

Illinois waterfowl: status and management

S. Havera

The eighth year of this study was completed and will culminate in a book treating a variety of topics relating to waterfowl: wetland habitat, food habits, nesting information, population analyses, banding results, harvest information, and waterfowl management. The Illinois and Mississippi river valleys were monitored during fall migrations from 1948–1988. Analyses of peak numbers of mallards since 1948 demonstrate the impact sedimentation has had. Approximately 80% fewer mallards pass through the Illinois Valley in autumn today because of the degradation of its aquatic habitat and the loss of natural foods for waterfowl.

Lead poisoning in Illinois waterfowl

S. Havera, W. Anderson

A comprehensive study was completed and published as Biological Note 133: "Lead Poisoning in Illinois Waterfowl (1977–1988) and the Implementation of Nontoxic Shot Regulations." It includes a compilation of data on abundance of spent shot in soil and sediment, ingested shot in gizzards, concentrations of lead and protoporphyrin in blood and/or liver, and lead poisoning die-offs in Illinois from 1977 to 1988. Also documented are nontoxic shot regulations in Illinois (past, present, and future), and how these regulations were affected by legislative actions and lawsuits.

Human disturbance of waterfowl

S. Havera

A 3-year study on Keokuk Pool monitored the effects of human disturbance on diving ducks during fall and spring migrations. Waterfowl were disturbed (forced to fly) an average of 4.8 times a day in fall and 6.8 times a day in spring by boating, barge, and shore activities on the 19-mile stretch of the river monitored. One area of high waterfowl use incurred disturbance 11 times a day in fall and 13 times a day in spring. Disturbance may help to explain declining numbers of diving ducks in fall since 1980, and refuges inviolate to boating may be imperative during fall and spring migrations.

Monitoring lead poisoning in mallards

S. Havera

Blood samples from dead lead-poisoned mallards were compared to samples taken from the same birds just prior to death. Blood taken from heart auricles 4, 8, and 24 hours after death had significantly lower lead concentrations than blood taken immediately before death; however, all samples had lead concentrations above established background concentrations. Although determining concentrations of lead in blood from dead waterfowl produces conservative estimates, this technique may nevertheless prove acceptable for monitoring lead contamination in waterfowl.

Pheasant and prairie-chicken interactions

R. Westemeier

Efforts by the Illinois Department of Conservation to control pheasants on the Jasper County Prairie-chicken Sanctuaries appear to be succeeding. Spring counts of crowing pheasant cocks showed declines from at least 92 in 1986 to 15 in 1989. Only 5 pheasant eggs were laid in artificial nests containing plastic eggs in April–May 1989, in contrast to heavy parasitism in fake nests during the previous 3 springs. In contrast to 1986, no pheasant eggs were found in 15 prairie-chicken nests examined in 1988 and 1989, although a bobwhite nest and a mallard nest were parasitized in 1988. Finally, no pheasant nests were found in 136 acres of key sanctuary grasslands in 1989.



Declining reproduction by prairie-chickens

R. Westemeier

The hatch rate for prairie-chicken declined from 1963 through 1989 in Jasper County. Parasitism by pheasants is one explanation, but the downward trend was also observed for unparasitized nests beginning about 1985. The 1980s were years of high pheasant abundance, and interactions with prairie-chickens were common. Egg fertility appeared to begin a downward trend, and clutch size showed considerable annual variation but no downward trend. Declining fecundity due to inbreeding depression is possible, but the pheasant cannot be discounted as responsible for the decline in hatch rate and possibly for the decline in egg fertility, even among unparasitized nests.

Waterfowl on Keokuk Pool

S. Havera

In the springs of 1977 and 1981–1988, the physiological condition of live-trapped lesser scaups, canvasbacks, and ring-necked ducks on Keokuk Pool was monitored. In 1985 and 1986, birds were also fluoroscoped to detect embedded and ingested spent shot, and blood samples were taken to determine lead levels. The body condition in spring of lesser scaup at Keokuk Pool will be compared to their condition on migration areas in northern Minnesota and on wintering grounds along the Gulf Coast of Louisiana. One focus of the study is on lead poisoning in diving ducks during spring migration; another examines their body condition in spring.

Effects of redosing mallards with lead shot

S. Havera

Waterfowl are subject to spent lead shot on their breeding, migration, and wintering areas. Often individual birds ingest one lead pellet and subsequently ingest a second or third. Control mallards were given no lead shot and each member of the dose and redose groups was given one No. 4 lead pellet. After 35 days, the redose group was given a second No. 4 lead pellet. Body weights were recorded and lead content in blood and tissue samples were measured to determine the accumulation of the toxin after the ingestion of the second pellet. Results should provide insights into the sublethal effects of lead poisoning in waterfowl.

Bluebirds in west-central Illinois

S. Havera
Eastern bluebirds have been declining regionally in recent years principally because of decreasing nesting habitat. This study evaluated reproductive success, territoriality, survival, and homing of eastern bluebirds. In 1988, 54 bluebird houses were monitored. Thirty-two nests were found with one egg each and 23 (72%) successfully fledged young. Fourteen males nested with 15 females in 1988 compared with 9 nesting pairs in 1985, 5 in 1984, 6 in 1983, 3 in 1982, and 6 in 1981. Ninety-one nestlings were banded in 1988 compared with 55 in 1985, 20 in 1984, 29 in 1983, 12 in 1982, and 42 in 1981. Eleven of 27 adults examined in 1988 had been banded previously and returned.

Harvest residues of waste grain

R. Warner, S. Havera, L. David, R. Siemers
Analyses of the abundance of waste grain and harvest residue in relation to fall tillage practices were completed. Compared to untilled fields, fields disturbed in autumn by reduced tillage typically had 50–60% less harvest residue on the soil surface and 65–80% less waste grain by late fall. Mean amounts of waste corn in untilled fields in late fall ranged from 60 to 431 kg/ha (dry wt) annually and declined about 55% by early spring; waste soybeans in untilled fields ranged between 34 and 63 kg/ha annually in late fall and declined about 85% by early spring.

Bird hazard algorithm

R. Larkin, D. Quine, D. Mattox
A self-contained procedure was developed to recognize dispersing starlings and blackbirds on large weather radars. The procedure uses an image-processing technique, the Hough Transform, to locate masses of birds departing the roost. About 6,000 migrating birds were recorded on the Survey's tracking radar. In addition, fall studies of migrating snow geese and Canada geese were continued.

Dispersal of wild soybeans

T. Hymowitz, R. Larkin
The ancestors of modern *Glycine* cultivars were first grown in eastern China. Related species occur in modern China and in Australia, but no relatives occur between these geographical areas. Investigators conclude from chromosomal and natural history information that migratory birds probably carried seeds of wild soybean plants across the Equator to Australia.

Trace element analyses

S. Wood
Trace elements were analyzed during the year in samples received from private citizens, University of Illinois staff and graduate students, Urbana and Champaign Sanitary District, City of Urbana, Northern Illinois Water Corporation, Waukegan Park District, and Lake County Health Department. Samples included tissue from the Section's prairie-chicken and mallard lead poisoning projects, mink tissue from the Illinois Department of Conservation, and fish tissue from the Crab Orchard Lake Project of Southern Illinois University and from lakes monitored by the Lake County Health Department. In progress is an extensive screening for lead of water fountains in Unit 7 District Schools.

Pesticide and PCB analyses

S. Wood
Samples tested during the past year came from private citizens, Survey staff, City of Urbana, several University of Illinois departments, Urbana and Champaign Sanitary District, Lake County Health District, two local businesses, Southern Illinois University, and the University of Chicago. PCB analyses on fishes collected from Crab Orchard Lake continue as part of a project of Southern Illinois University to ascertain effects of the old Sangamo Electric Company's dump site on the biota of the lake. Also in progress are analyses of pheasant tissue from the Section's prairie-chicken project and fish tissue from lakes being monitored by the Lake County Health District.

Wood duck book

F. Bellrose
In the United States, the wood duck nests almost exclusively in habitats shunned by other species. With harvest controlled, it has risen from near extinction in the early 1900s to the second most important duck in the bag of American hunters. Near completion is a book on the wood duck that covers 50 years of research at the Survey and findings from 800 other investigators. Analyses of 445,378 bandings and 46,344 recoveries show annual survival at about 50%—highest in adult males and lowest in immature females. Hunters take about 20% of the birds and natural mortality the rest. The moderate harvest of wood ducks, unlike that of mallards, has a depressing effect on survival.





FINANCIAL STATEMENT

The financial position of the Survey remained precarious throughout the year and again proved a major constraint on research, service, and activity at all levels. The Survey realized little in the way of financial relief through increased appropriations, and programming levels could not be increased; indeed, current levels were maintained only with great difficulty. The table below summarizes the financial profile of the Survey for Fiscal Year 1989. Included are the General Revenue Fund, the Lands Unsuitable for Mining Program, and Miscellaneous Funds.

Financial Statement of the Illinois Natural History Survey, Fiscal Year 1989. Values are given in thousands of dollars.

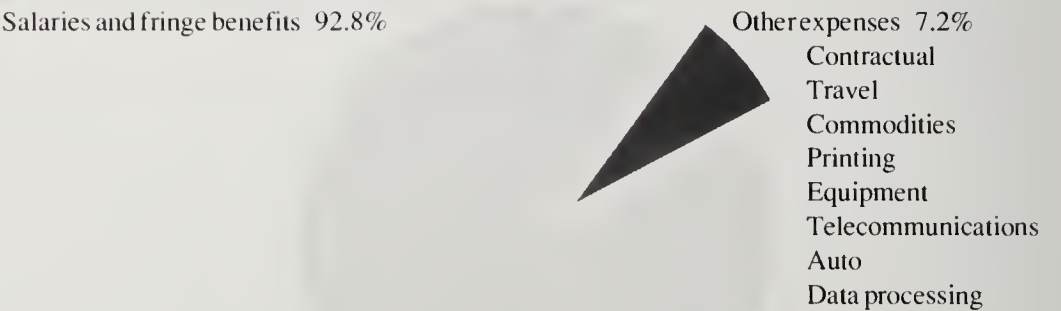
Accounts	FY 88 Actual	Appropriations including transfers	FY 89 Actual	Percent change
General Revenue Fund				
Personal services	\$2,854.7	\$2,857.4	\$2,857.4	+0.1
Retirement contributions	285.6	291.8	291.8	+2.2
Social security contributions	2.1	2.8	2.8	+33.3
Contractual services	69.9	67.7	67.7	-3.2
Travel	4.8	4.8	4.8	0.0
Commodities	36.5	39.9	39.9	+9.3
Printing	18.9	14.7	13.9	-26.5
Equipment	22.9	23.9	23.3	+1.8
Telecommunications	54.4	57.3	57.3	+5.3
Operation of auto equipment	34.6	32.5	32.5	-6.1
Data processing	2.3	2.2	1.9	-17.4
Total	3,386.7	3,395.0	3,393.3	+0.2
Lands Unsuitable for Mining Program				
Personal services	234.0	205.8	203.6	-13.0
Social security contributions	0.0	0.5	0.5	+100.0
Group insurance	9.7	7.3	7.3	-24.7
Contractual services	10.0	5.0	5.0	-50.0
Travel	5.9	4.2	4.2	-28.8
Commodities	9.5	0.8	0.8	-91.6
Equipment	1.6	0.0	0.0	-100.0
Telecommunications	8.4	25.4	25.3	+201.2
Operation of auto equipment	2.6	0.0	0.0	-100.0
Data processing	60.8	73.1	69.6	+14.5
Total	342.5	322.1	316.3	-7.7
Miscellaneous Funds				
Repair and maintenance	38.4	38.4	38.4	0.0
Maintenance of major equipment	16.8	18.7	16.1	-4.2
Total	55.2	57.1	54.5	-1.3

40 As the pie chart below illustrates rather dramatically, appropriations to the various operating lines continued to be a vexing problem during the past year. Over 92 percent of the total budget was allocated to salaries and fringe benefits; only \$243,000 or 7 percent could be spent in all other areas. Because increased costs are associated with all activities of the Survey, operating line appropriations must be increased if the Survey

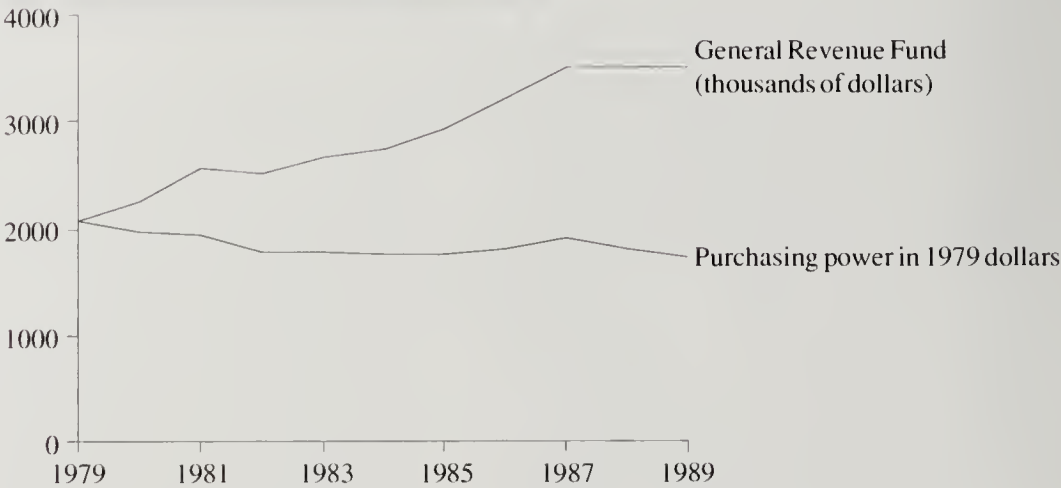
is to continue to carry out its legislative mandate. Never in the more than a century of service to the citizens of Illinois has the Survey's mission been more important. The environmental issues that are so clearly related to the economic health of the State, to the well being of its citizens, and to the survival of its diverse flora and fauna can no longer go unaddressed, and the Survey must inevitably play a major role in that endeavor.

Appropriations to the General Revenue Fund have increased very little over the past ten years. Although a modest growth is evident in dollars allotted, the effects of inflation on the budget have proved devastating. When the budget is expressed in terms of the purchasing power of 1979 dollars, we discover that the increases are largely illusory. In practical terms, as pictured on the line graph below, no real growth has been experienced by the Survey in more than a decade.

Allocation of General Revenue Fund



Effect of inflation over ten years





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- Committee of the Prairie Hills Resource Conservation and Development Area, Ducks Unlimited Committee for designing a wood duck box, Fulton County Tourism Council.
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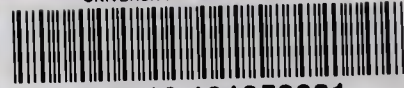
Published by authority of the State of Illinois
James R. Thompson, Governor

Design: David M. Murrel
Photographs: Molly Hardin Scott, Michael Jeffords, and the archives of the Illinois Natural History Survey
Editors: Audrey S. Hodgins and Eva L. Steger

351095-500-11-89

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